50th Annual Fuze Conference

"50 Years of Support Freedom"

9 - 11 May 2006

Norfolk, Virginia

Session I & II: *OPENING REMARKS AND KEYNOTE & GENERAL SESSION*
• **Keynote: Mr. Rene Kiebler**, Deputy Project Manager Combat Ammunition Systems, PEO Ammunition
• OSD Perspecctive, **Mr. Peter A. Morrison**, Staff Specialist OUSD/DDR&E(S&T) Weapons Technology
• PEO Ammo Perspective, **Mr. Rene Kiebler**, Deputy Project Manager Combat Ammunition Systems, PEO Ammunition
• US Army RDECOM ARDEC Perspective, **Dr. Joseph Lannon**, US Army RDECOM ARDEC
• Navy Overview, **Mr. Steve Mitchell**, Ordnance Project Area Director, NAVSEA
• Air Force S & T Strategy, **Mr. Timothy Tobik**, Air Force Research Laboratory, Eglin
• Air Force Acquisition Strategy, **Mr. J. Rick Holder**, Sr., Director Fuze Squadron USAF, Eglin
• Fuze IPT Perspective, **Mr. Lawrence Fan**, Fuze and Microsystem Project Manager, NSWC

Session IIIA: *OPEN SESSION*
• PGMM, New Application for an Existing Fuze, **Mr. Al DeSantis**, Picatinny Arsenal, NJ
• Proximity Sensor for the Guided Multiple Launch Rocket System (GMLRS), **Mr. Robert P. Hertlein**, L3 Communications - KDI Precision Products
• Portable Excalibur Fire Control System, **Mr Gregory Schneck**, US Army RDECOM ARDEC
• Enhanced Portable Inductive Artillery Fuze Setter (EPIAFS), **Mr. Tom Walker**, US Army RDECOM ARDEC Adelphi Fuze Division
• The Evolution of the DSU-33 C/B Proximity Sensor, A Success in Customer-Contractor Partnership, **Mr. Michael J. Balk**, ATK Ordnance Systems
• A New Fuze for an Electromagnetic Gun, **Mr, Barry Schwartz**, US Army RDECOM ARDEC
• Introduction of the Multi Option Fuze Artillery (MOFA) DM84 on 120mm Rifled Mortar, **Mr. Jochen Wagner**, JUNGHANS Feinwerktechnik

Session IVA: *OPEN SESSION*
• Challenges Associated with Development of the Affordable Weapon System Fuzing System, **Mr. John Hubert**, L-3/KDI Precision Products, Inc.
• FMU-139C/B. Electronic Bomb Fuze Design Update, **Mr. David Liberatore,** ATK
• Shipboard Submunition Fuze Safety and Realiability Enhancements, **Mr. John Kunstmann**, Indian Head Division, NSWC
• Thermal Battery Development - Reduced Product Variability Through 6-Sigma, Automation and Material, **Mr. Paul F. Schisselbauer** and **Mr. John Bostwick**, ATK
• Performance Testing of Lead-Free Stab Detonators, **Mr. Neha Mehta**, US Army RDECOM ARDEC
• TNO Research on EFI's in Relation to Insensitive Munitions, **Mr. Wim Prinse**, TNO Defence, Security and Safety

Session VA: *OPEN SESSION*
• Hight-G Mortar Electronic S&A Development and Flight Test, **Mr. Cuong Nguyen**, US Army RDECOM ARDEC
• Safe Separation Study for MK 437 Mult-Option Fuze for Navy (MOFN), **Mr. Brian Will**, NSWC, Dalhgren
• Navy Proximity Fuze Simulation with Embedded Tactical Software, **Mr. John Langan**, NSWC WD
• Inadequacy of Traditional Test Methods for Detection of Non-Hermetic Energetic Components, **Mr. Karl Rink**, University of Idaho
• Weapons Reliability How Modern Warfare has Changed the Requirement, **CDR Tom Hole**, USN, US Navy PMA-201
• MAFIS a Proven Hard Target Fuze, **Mr. Laurie Turner**, Thales Missile Electronics
• Aurora a Proven Hard Target Fuze, **Mr. Richard Clutterbuck**, Thales Missile Electronics

The Evolution of the DSU-33 C/B Proximity Sensor, A Success in Customer-Contractor Partnership

Wednesday May 10, 2006

Michael J. Balk
ATK
763.744.5094

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NDIA Fuze Conference
Norfolk, VA

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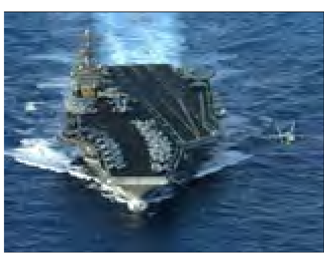




"I am always doing that which I can not do, in order that I may learn how to do it."

Pablo Picasso

Agenda

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DSU-33 Overview

DSU-33C/B Development Goals

DSU-33 C/B Design Description

- Approach
- Technologies

Testing Completed

Performance

Questions

DSU-33 Description

System Description

- Radar Proximity Sensor
- Provides Height of Burst (HOB) fire pulse signal to the fuze for JDAM and GP bombs (FMU-139 & FMU-152A/B Fuzes)

Performance Parameters

- Height of Burst: 5 – 35 Feet (80%)
- Multiple Weapon Release: 2 or more
- Operational Life: 200 Seconds
- Storage Life: 10 Years

DSU-33 History

Circa 1970's a desire arises to improve and combine the performance of the Mk 20 and Mk 43 Target Detectors

DSU-33/B is developed and evolves into the DSU-33A/B

1990-1995 Motorola produced DSU-33A/B's for the U.S. Air Force

1998 DSU-33B/B JDAM design upgrade is completed

2000 ATK begins production of DSU-33B/B's

DSU-33C/B Timeline

ATK

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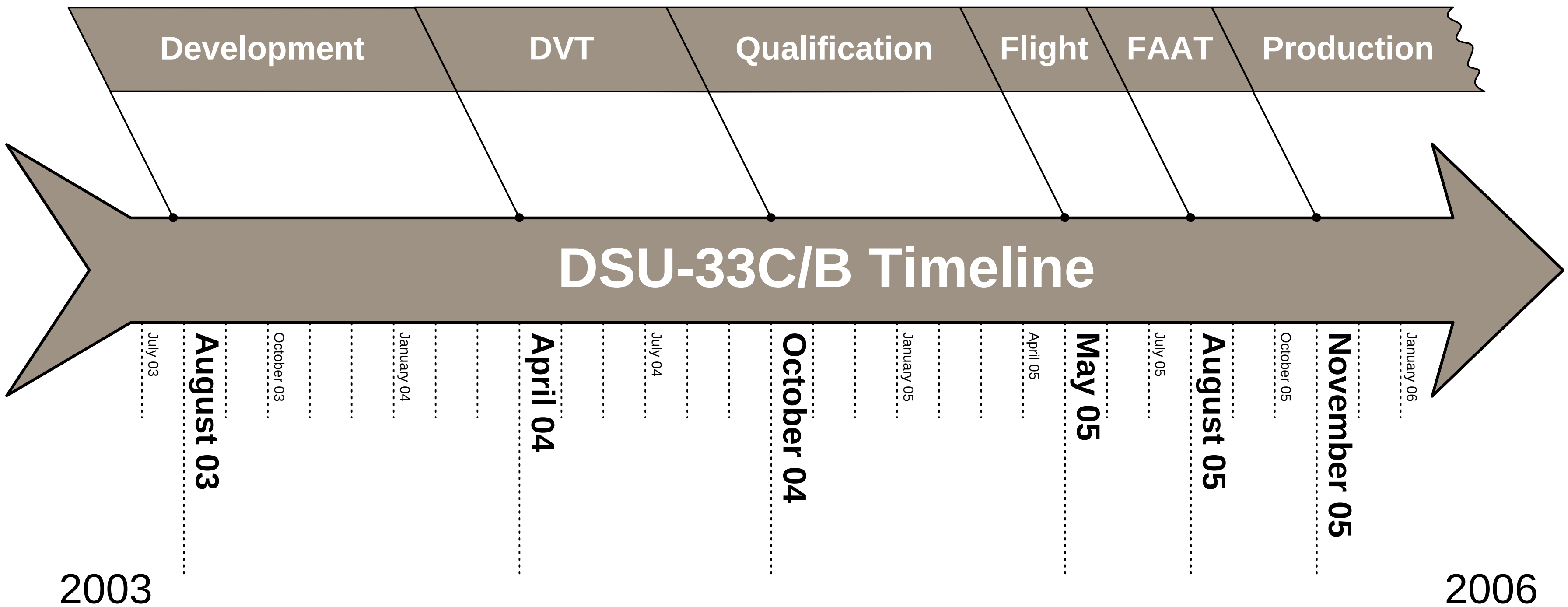

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DSU-33C/B Development Goals

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✓ DSU-33 C/B Performance	$\geq$	DSU-33 B/B Performance
✓ DSU-33 C/B ICD	=	DSU-33 B/B ICD
✓ DSU-33 C/B UPC	<<	DSU-33 B/B UPC

DSU-33C/B Development Objectives

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Address Parts Obsolescence

Improve HOB Accuracy

Reduce the Material Cost

- Eliminate Parts
- Use Lower Cost Parts
- Lower the Cost of Current Parts

Reduce Labor Cost

- Fewer Parts to Assemble
- Easier to Assemble
- Less Rework
- Less Test Time

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Customer – Contractor DFMA

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When

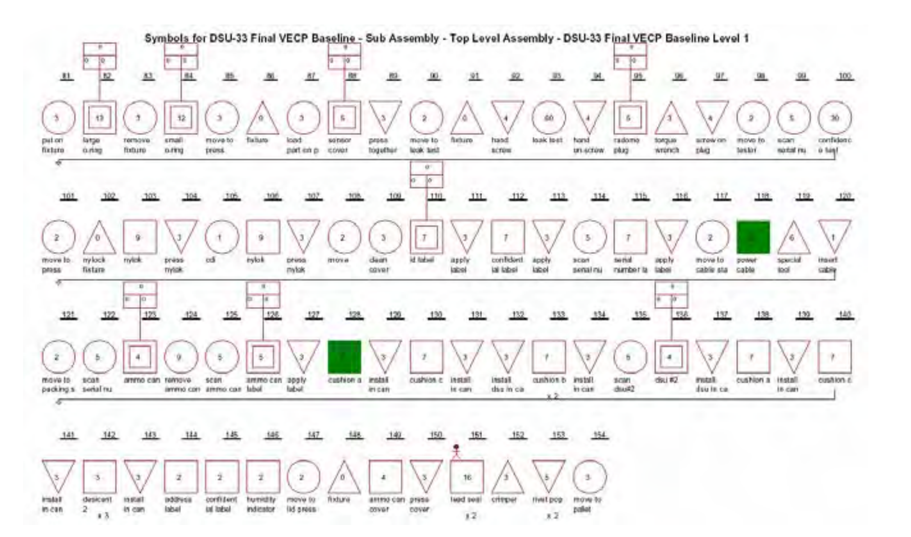
- Prior to the PDR

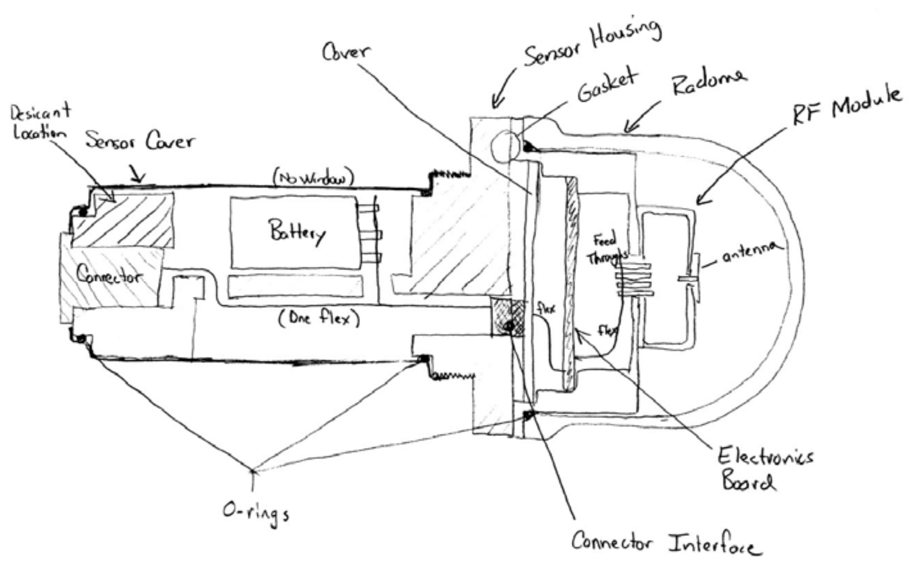
Benefits

- Customer involvement
- Production involvement
- Disciplined look at design approaches and costs
- Cross-functional exchange of ideas

Results

- Improved ease of assembly
- Reduced Material Cost





RF Module Producibility Improved

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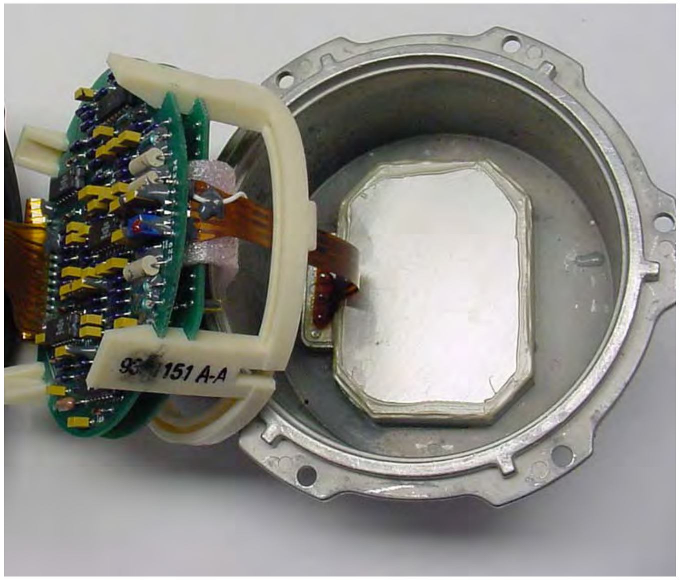

DSU-33B/B RF Design:

- 26 Components
- Discrete Oscillator Design
- Hand Assembled in Electronics Housing

DSU-33C/B RF Design:

- 7 Components
- GaAs MMIC Chip Transceiver
- Removable from Electronics Housing for Solder Reflow Oven

RF linearity C/B

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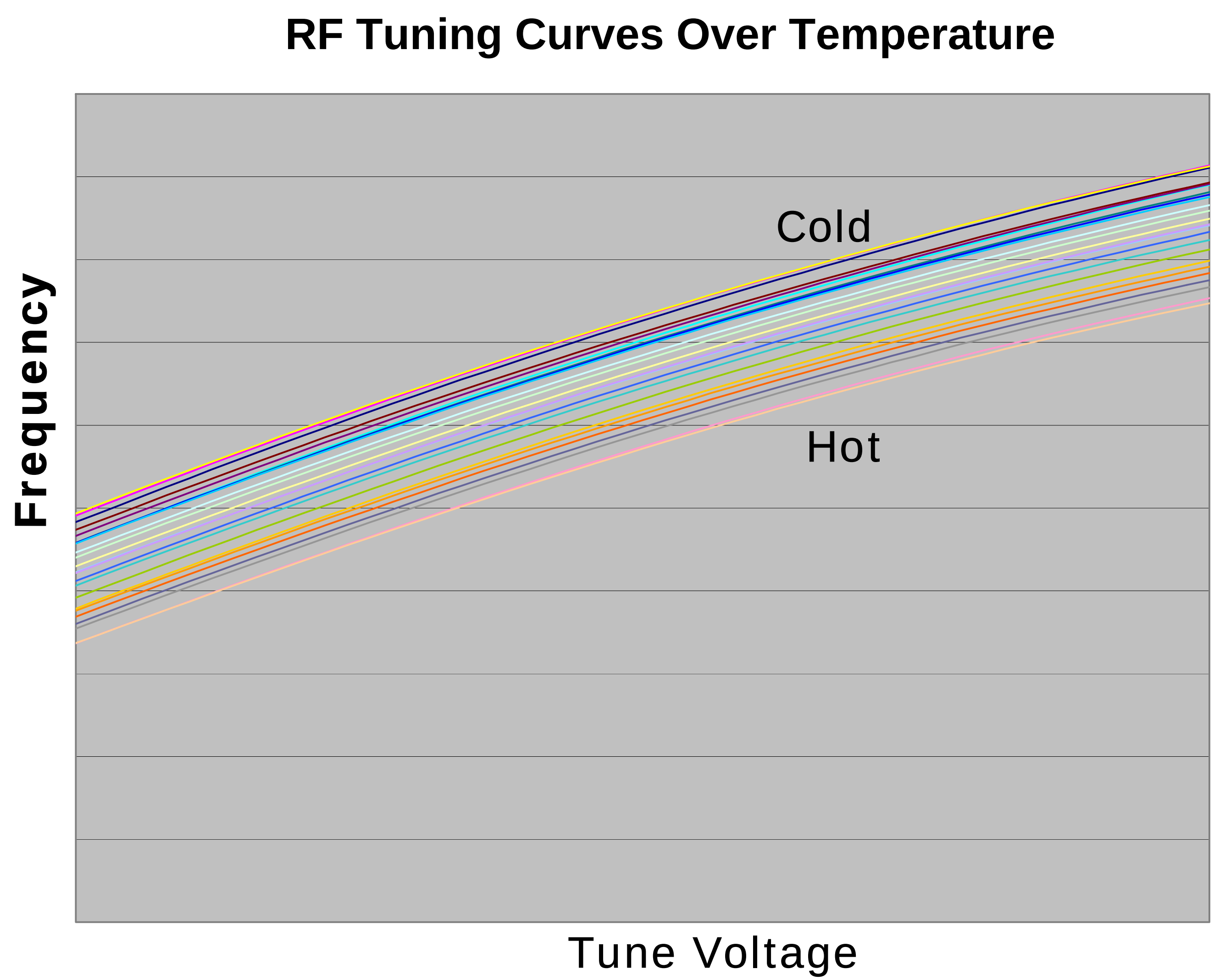

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Electronics Reduced to One SM CCA

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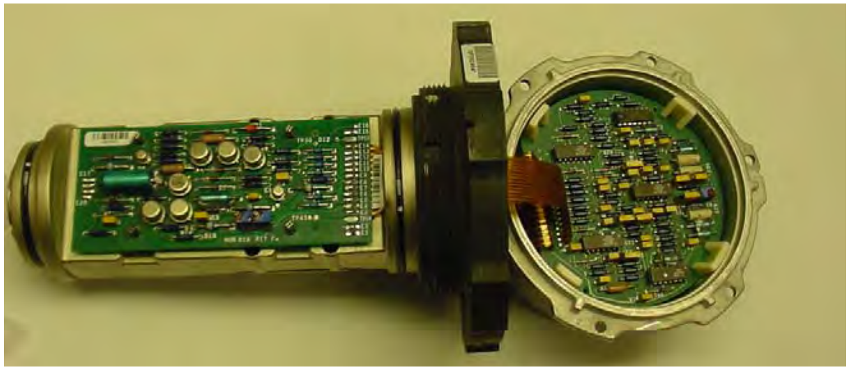
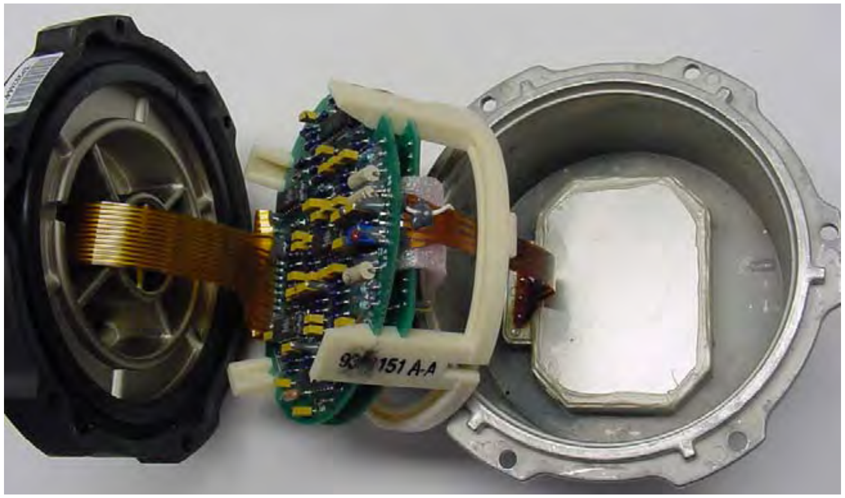
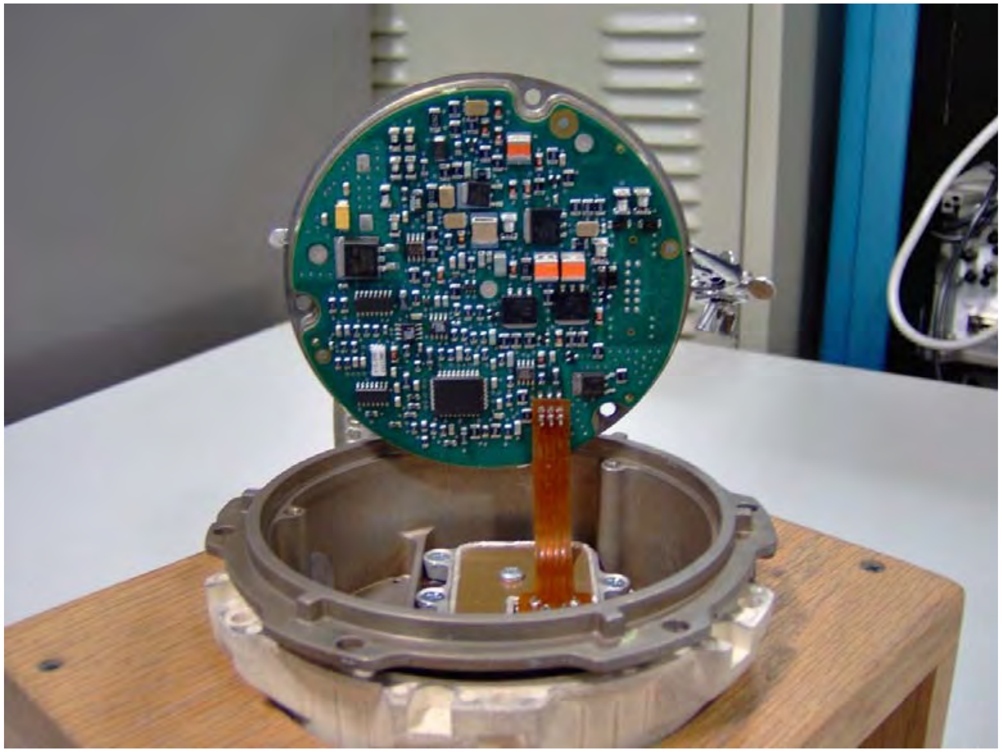
B/B Electronics (3 Boards)	C/B Electronics (1 Board)







DSU-33C/B CCA is Manufactured on an Automated Pick-and-Place Machine.

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DSU-33C/B Designed for Testablility

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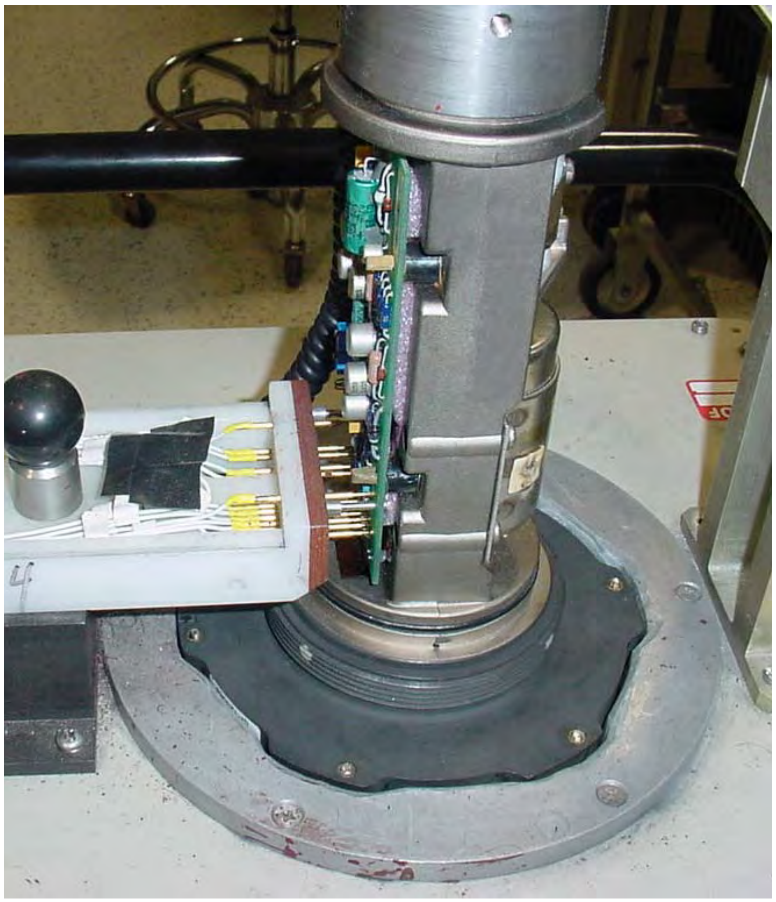
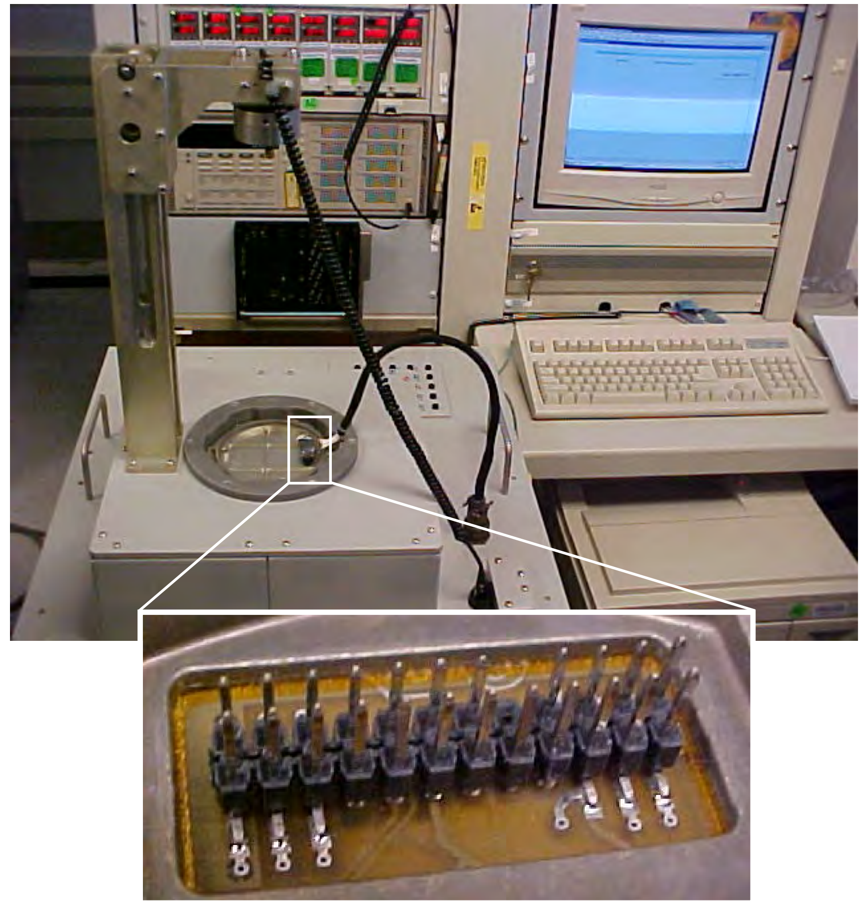
B/B Test Interface



C/B Test Interface



DSU-33C/B Test Interface is More Reliable and User Friendly.

DSU-33 Completed Testing

- ✓ Design Verification Testing
- ✓ Full Contractor Qualification
- ✓ Flight Testing
- ✓ First Article Acceptance Testing

HOB Process Capability

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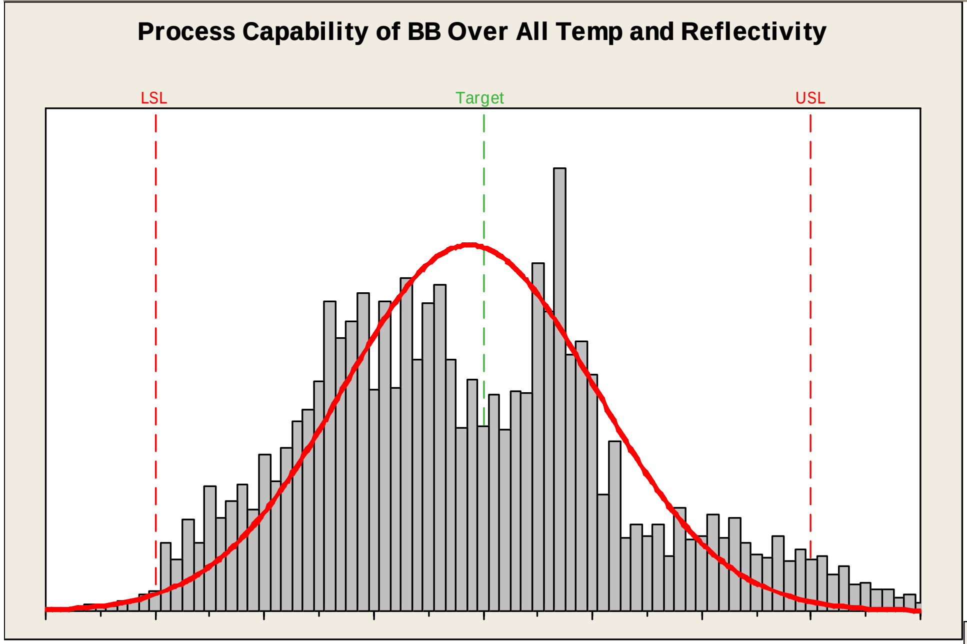
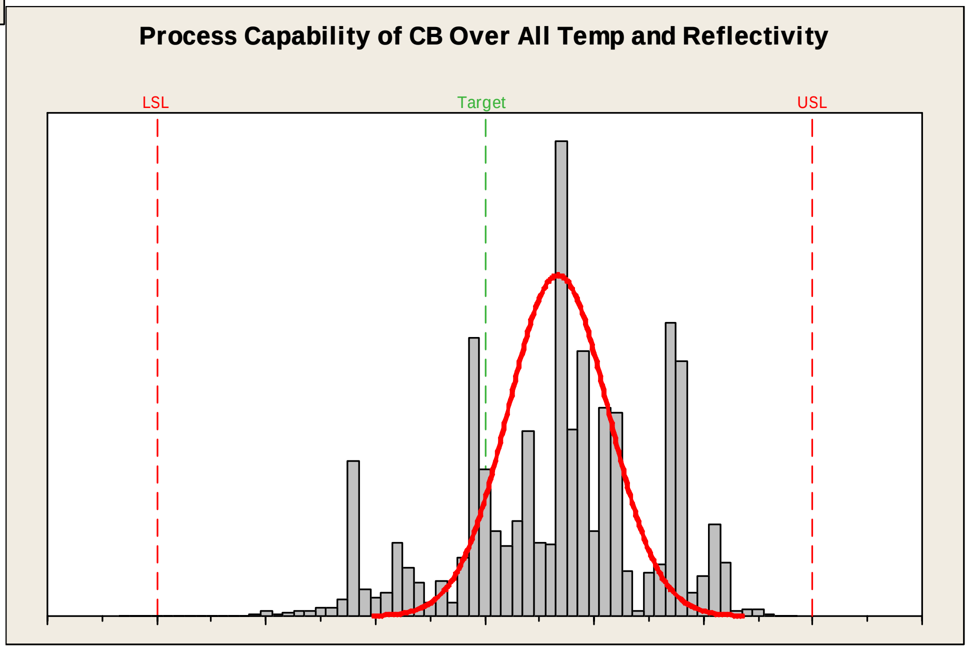


DSU-33B/B Performance:

- Mean is more than 2.5 standard deviations away from nearest spec limit (Requirement is 2).
- 99.6% Between Limits
- 1,672 Units in Sample

DSU-33C/B Performance:

- Mean is more than 5 standard deviations away from nearest spec limit (Requirement is 2).
- >99.9999% Between Limits
- 1,845 Units in Sample



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“If you think of standardization as the best that you know today, but which is to be improved tomorrow; you get somewhere.”

Henry Ford

QUESTIONS

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PGMM:
A New Application for an Existing Fuze

Precision Guided Mortar Munition

Al DeSantis, Picatinny Arsenal, NJ
Steve Thomas, Alliant TechSystems, Plymouth, MN

50Th Annual Fuze Conference
May 9-11, 2006
Norfolk, Virginia

Agenda

- Program Background
- System Overview
- Typical Mission Video
- PGMM Fuze and ETFM commonality
- Fuzing System Design
- Electronics Design
- Summary

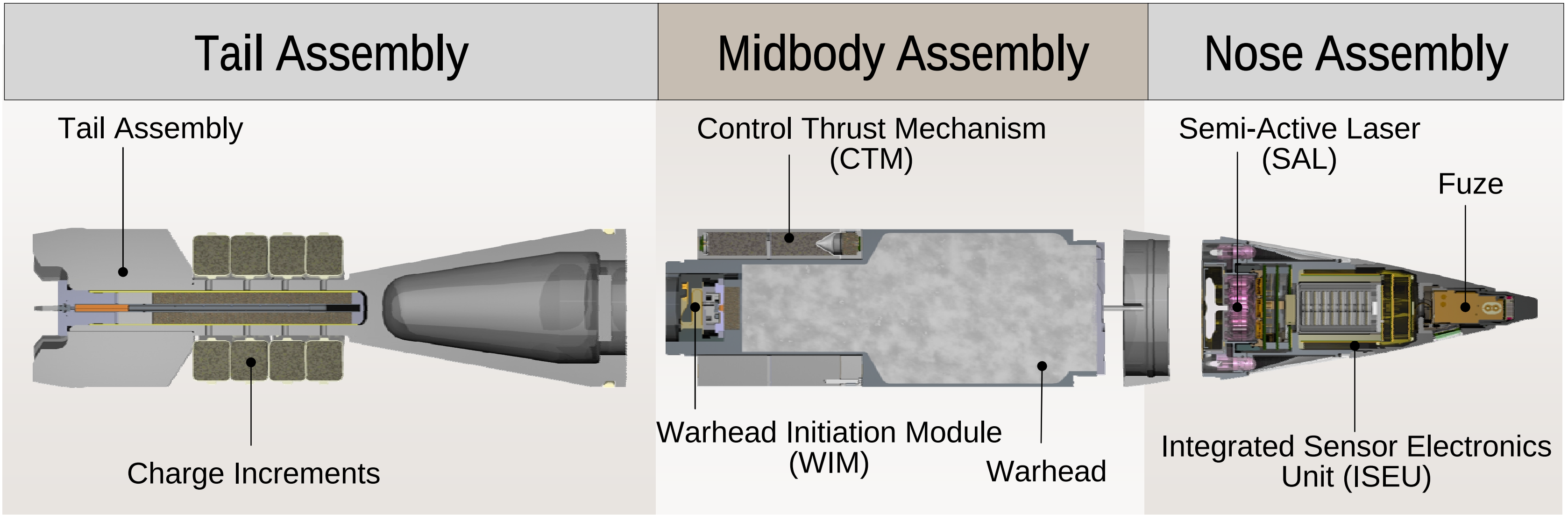
Program Background

XM395 - PGMM

Precision Guided Mortar Munition

Designed to provide point target accuracy against threat targets in urban theater where minimal collateral damage is desired

Program Background



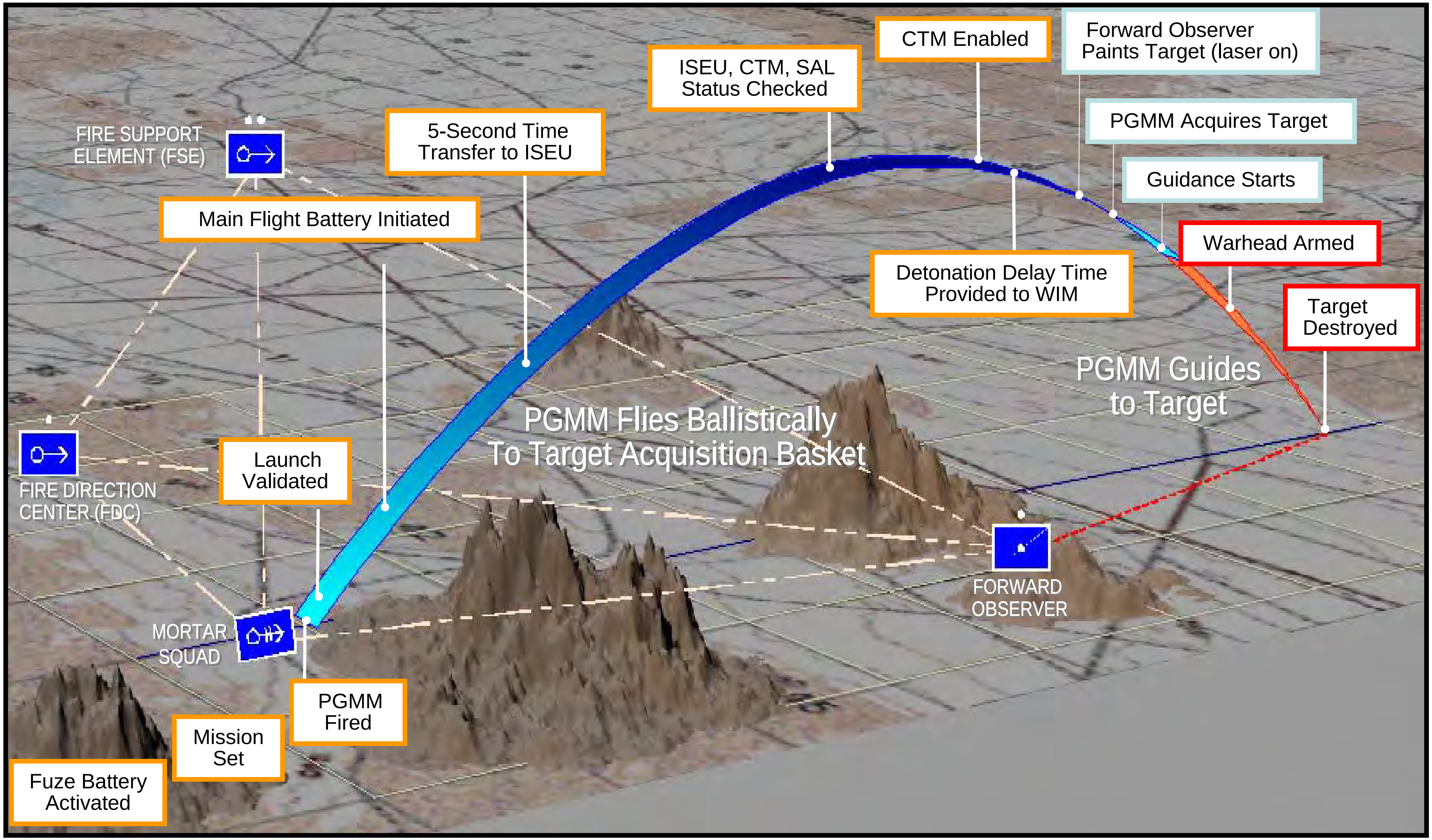
Precision Guided Mortar Munition (PGMM)

- Lethality – shall have the ability to defeat or incapacitate personnel protected within specified point targets.
- Range – shall be able to engage targets at ranges from 1000m to 7200m.
- Compatibility – shall be compatible with all 120mm firing platforms and munition handling systems without adding personnel or equipment to the organization (except for any PGMM-MFCS interface device).
- Reliability – shall have a functional reliability of 90% over a 10-year timeframe.

Mission Set Data

- Time of Flight
- Laser Code
- Mode (Delay based on target type)
- QE
- Zone Charge
- Cross Winds
- Downrange Winds

PGMM Fuze Mission Timeline



Typical Mission

Click to start video.

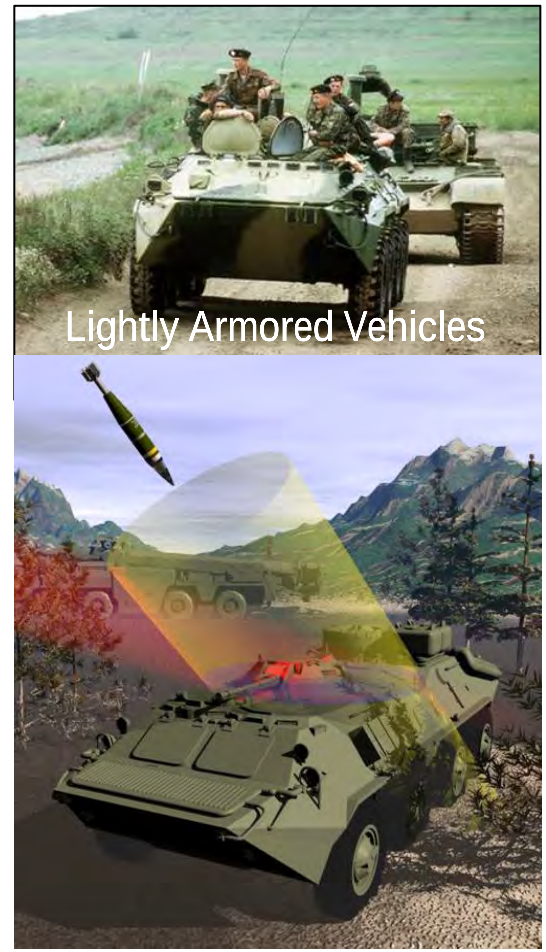
PGMM Key Milestones

- ✓ Contract Award – complete January ‘05
- ✓ System Readiness Review – complete March ‘05
- ✓ Initial Safety Review Board Briefing – complete May ‘05
- ✓ Preliminary Design Review – complete December ‘05
- ✓ Tactics, Techniques, & Procedures Demo – complete February ‘06
- ✓ First Guided Flight – complete May ‘06
- Critical Design Review – August ‘06
- Fuze Vertical Recovery Test – October ‘06
- Tactical Guided Flight Test – November ‘06

PGMM Target Set

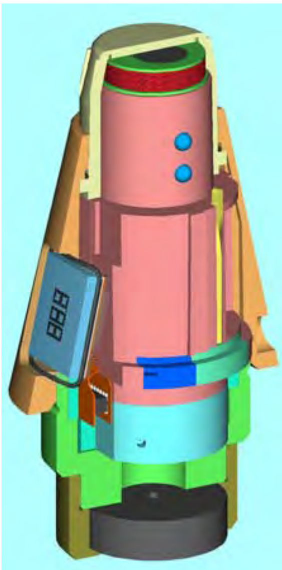
Earth & Timber Bunkers

Masonry Structures



Lightly Armored Vehicles

Fuze Commonality



XM784
ETFM

Timed Mortar Fuze for illumination rounds

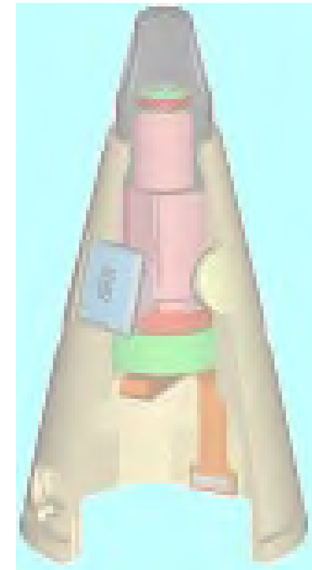
Fuze Assembly

- ✓ Dual-Processor Safety Architecture
- ✓ Fuze Battery & Activation Mechanism
- ✓ Muzzle-Exit Sensor (2nd Safety Environment)
- ✓ Manual Set Capability (LCD, Switch, Button)
- ✓ EOD Function
- ✓ S&A Arming
- ✓ Internal Housings
- Inductive Set Capability
- Main Flight Battery Initiation
- ISEU Data Communication Interface
- Control Thrust Mechanism Safety Enable

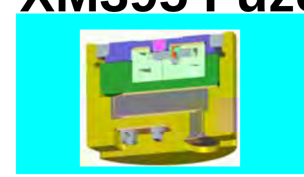
Warhead Initiation Module (WIM)

- ✓S&A – Set-Back Lock Mechanism (1st Safety Environment)
- Det-Delay Electronics
- Explosive Train

✓ Indicates Commonality with ETFM



XM395 Fuze

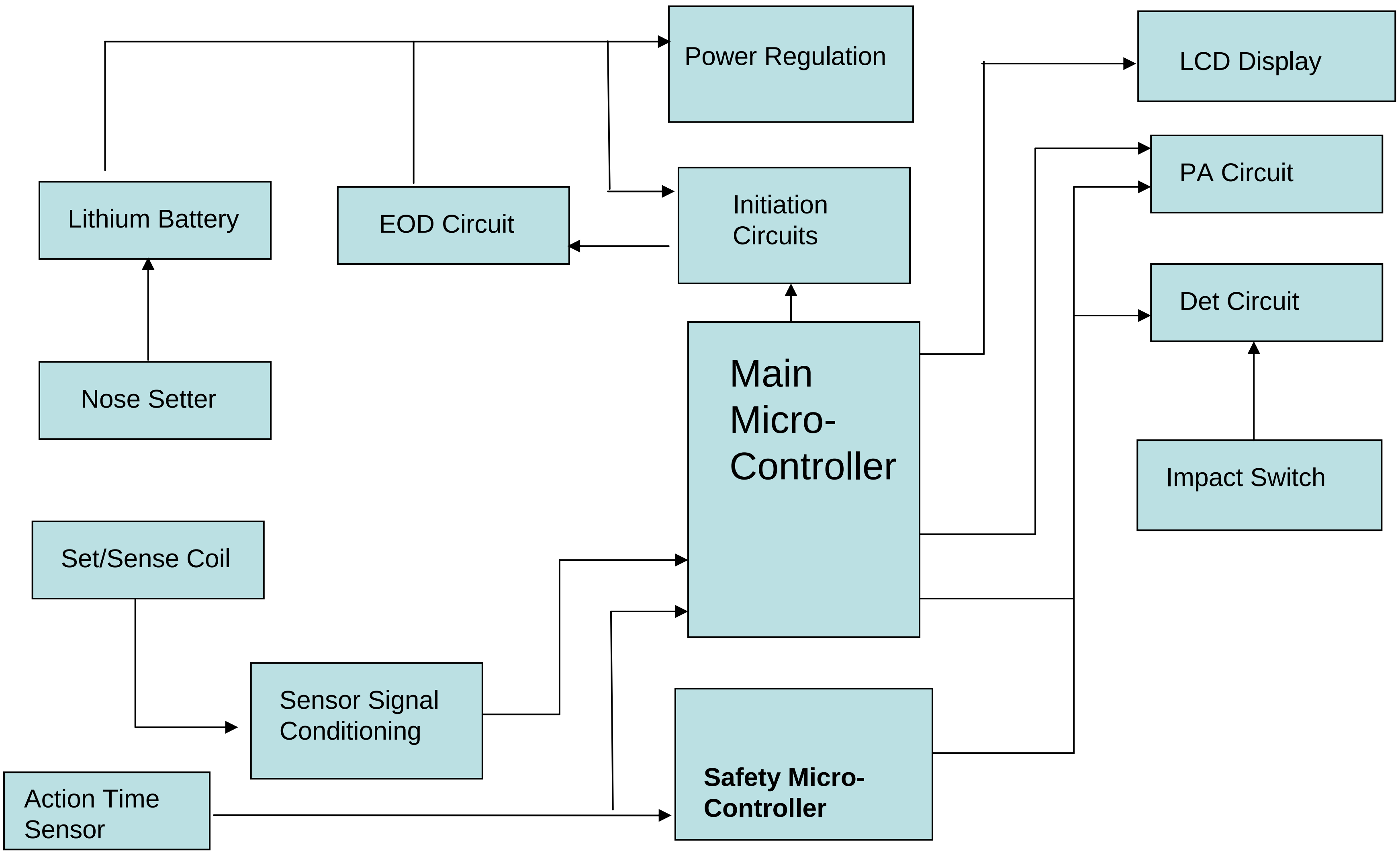


XM395 WIM

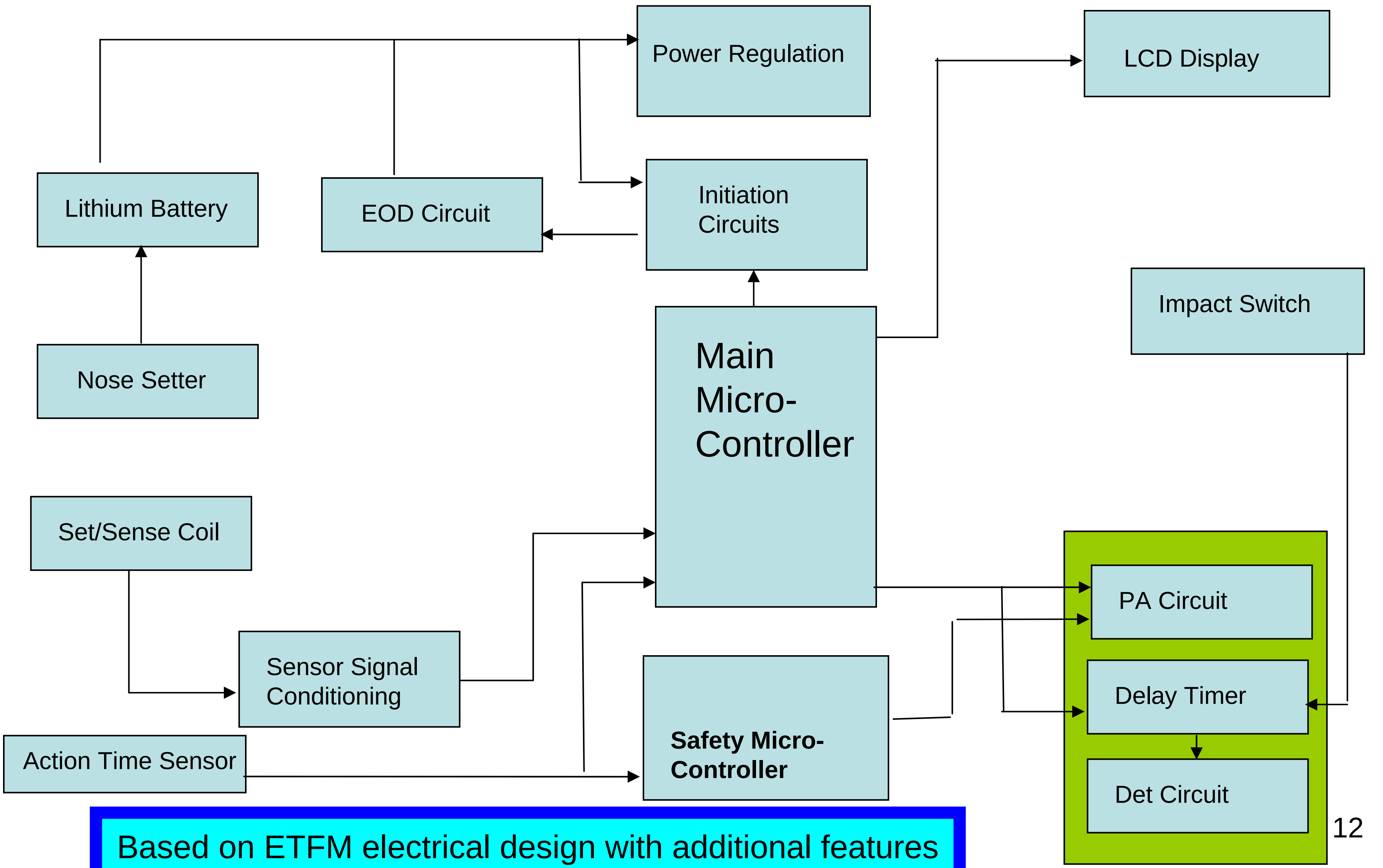
PGMM Fuze Leverages ETFM Design

Designed to Meet MIL-STD-1316E Safety Requirements

ETFM Electrical Block Diagram

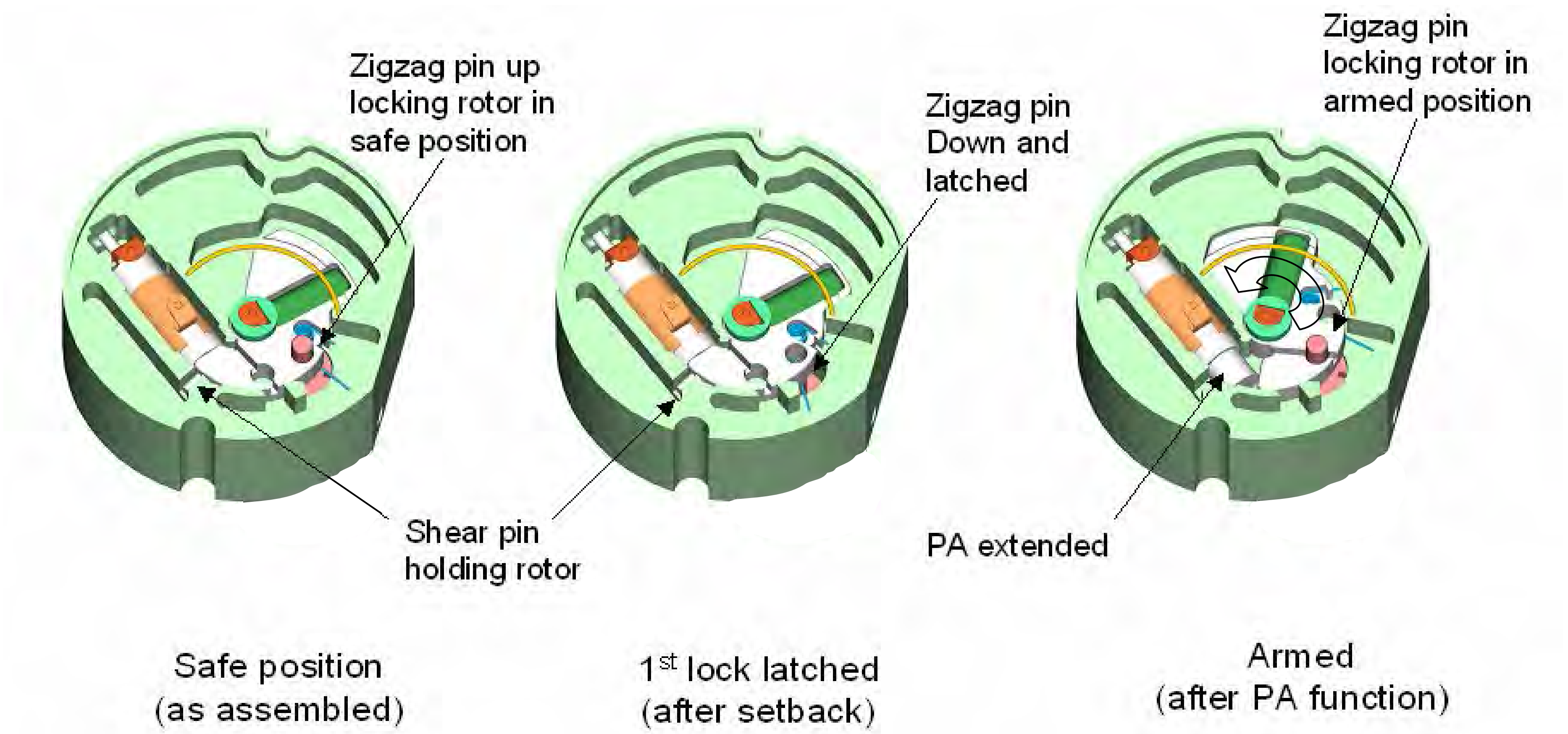


PGMM Fuze & WIM Electrical Block Diagram



Based on ETFM electrical design with additional features

PGMM Mechanical S&A



Based on ETFM mechanical S&A design
ATK Patent Number 5,693,906

Soldier Feedback

- The PGMM system is in great demand by the soldiers on the ground in Iraq
  - Maneuver Force: "It definitely builds our confidence. I mean, as an Infantry guy, mortars are one of the things you're most scared of. If you can put it within a meter, that's a reasonable window. This thing will be great." *TTP Demo, Fort Benning, GA, 17 Feb 06*

FO Team
FOS and Laser
Designator

M1064 Mortar carrier
MFCS & PGMM Slug
Rounds

Threat Sniper
Position after PGMM
Hit

Maneuver Squad
Attacking Village

Summary

- PGMM is a unique munition needed by the soldier in today's complex battlefield.
- Utilizing existing design concepts and parts has greatly reduced design time and cost
- Utilizing common parts will continue to keep the production costs down for both PGMM and ETFM
- This modular concept will allow for continued growth as increments are pursued to increase future capabilities.

PGMM:

Truly a New Application for an Existing Fuze

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KDI Precision Products, Inc.

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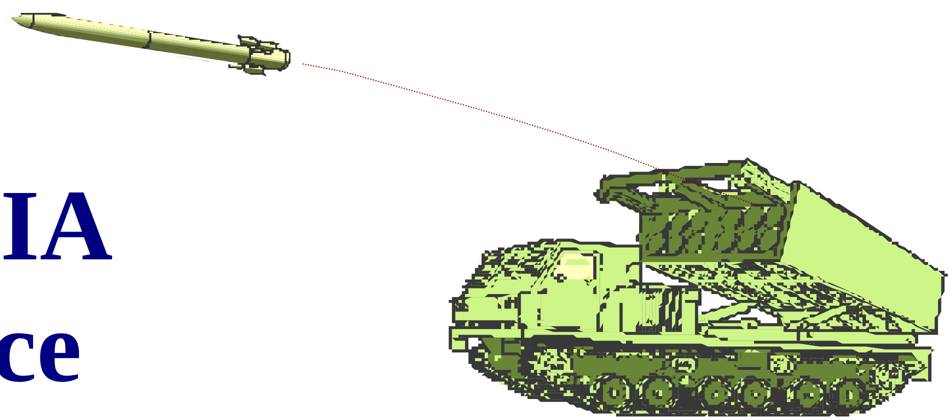
Proximity Sensor
for
Guided Unitary Multiple Launch Rocket System



50th Annual NDIA Fuze Conference

May 9-11, 2006

EDC
Electronics Development Corporation

Overview

- System Background
- System Requirements
- Design Challenges
- Design
  - Antenna/Radome
  - Electronics
    - Signal Processor
    - Transceiver

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System Background

- Multiple-Launch Rocket System (MLRS)
  - Legacy system
    - LRIP 1980
    - Ballistic trajectory
    - DPICM payload
  - GPS/IMU Guidance added 2000
  - DPICM payload with unitary 2002
    - Needed proximity sensor for maximum lethality
    - KDI/EDC turned on in December 2003

System Requirements

- Selectable Height of Burst (HOB) : 3m/10m
- 15º to 110º approach angle
  - Roll-stabilized
- 250m/s to 850m/s approach velocity
- Built-in-Test (BIT)

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EDC Electronics Development Corporation

Design Challenges

- Radome/Antenna
  - Thermal environment
    - Nose gets EXTREMELY hot
  - Cover push-through
    - Tube exit presents significant mechanical load
  - Broad angle of attack

Design Challenges

- Electronics
  - Velocity
    - Exceeds capabilities of existing transceiver/processor chip sets
  - BIT
    - Not available with legacy ASIC-based signal processors
- Aggressive Schedule
  - Approximately 13 months to CDR

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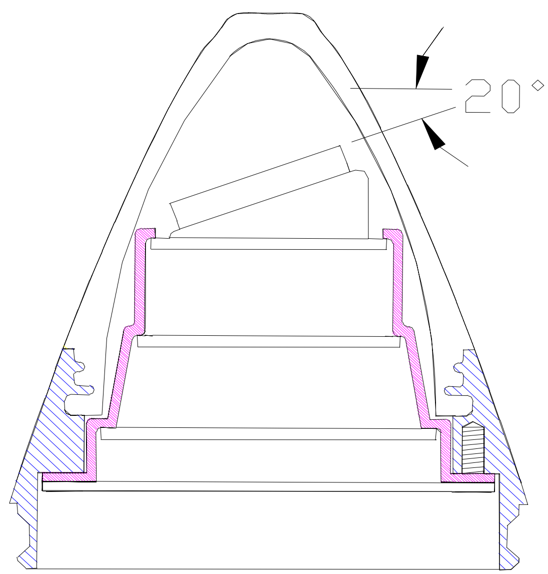
Radome/Antenna

- Proposed concept was simple patch antenna and plastic radome (PEEK)
  - Antenna would be tilted to provide shallow angle coverage
  - PEEK has been used in rocket applications



Radome/Antenna

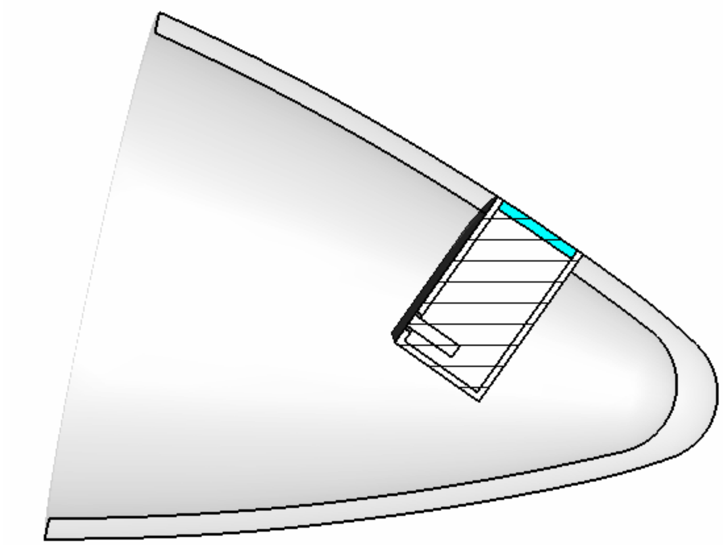
- LM concerned about thermal and mechanical radome environments
  - High temperature due to velocity
  - Severe tube-exit mechanical stress
- After contract award, LM analysis shows that PEEK won’t with stand environments
  - Suggest that nose must be metal…..!

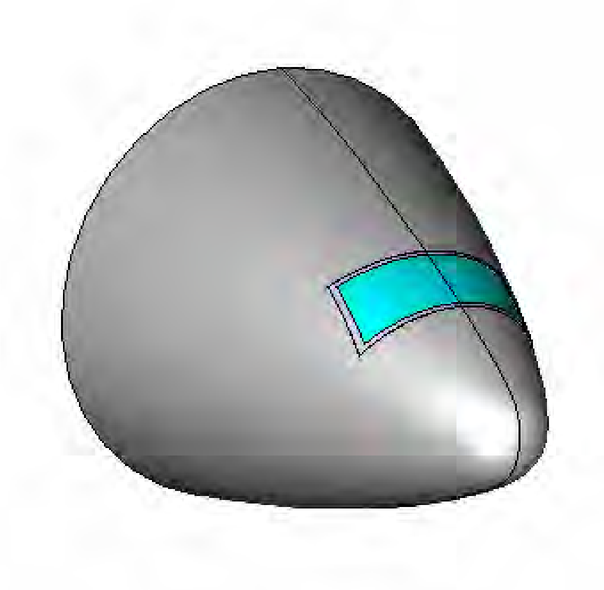
Radome/Antenna Concepts

- A window on the side of a metal nose would be provided for the antenna
- Various concepts were considered
  - Waveguide aperture
  - Patch antenna mounted in/under window
- Analysis tool was needed
  - KDI acquired a 3D EM analysis tool to quickly evaluate various options

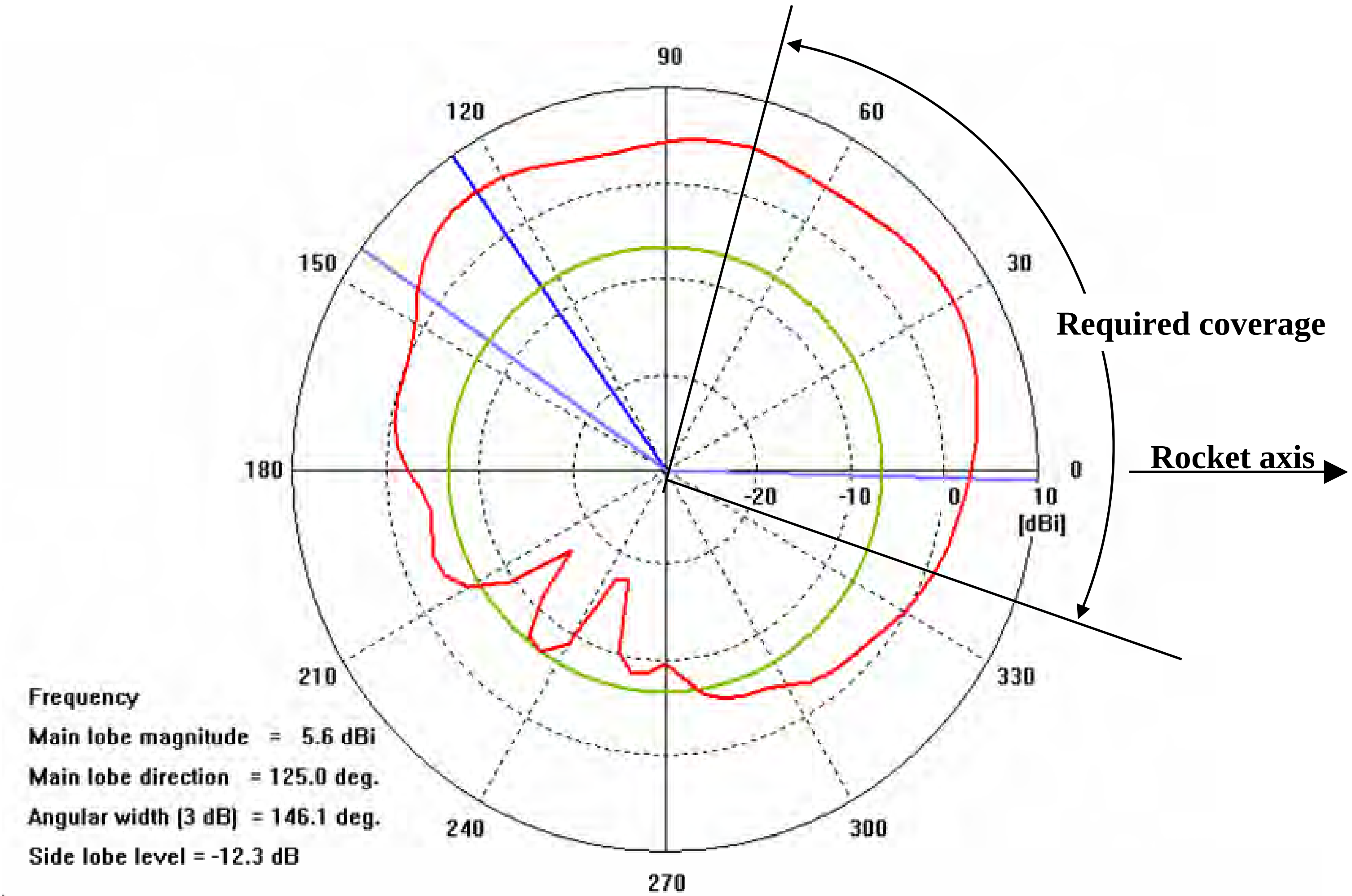
Waveguide Aperture

- Window would form waveguide aperture
  - Provided good coverage
  - Not practical to build/assemble



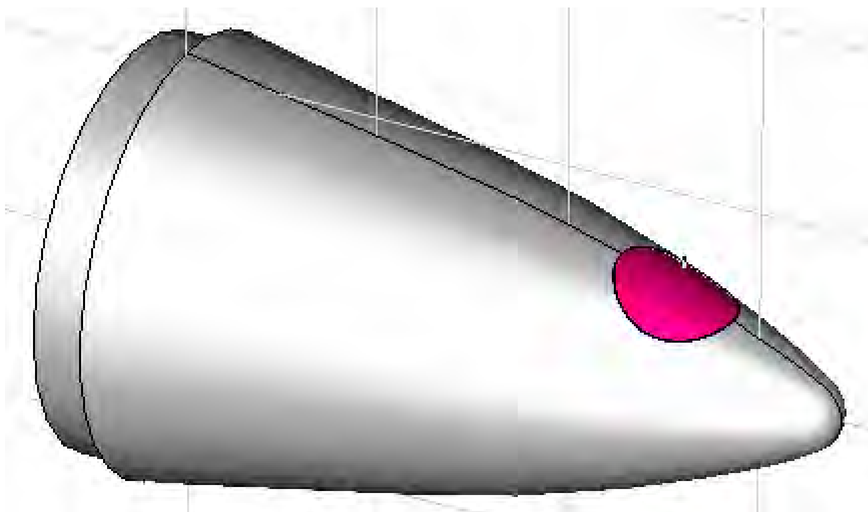


Waveguide Aperture



Patch Under Window

- Simple patch antenna mounted under window
    - Difficult to mount
    - Less-than-optimal pattern



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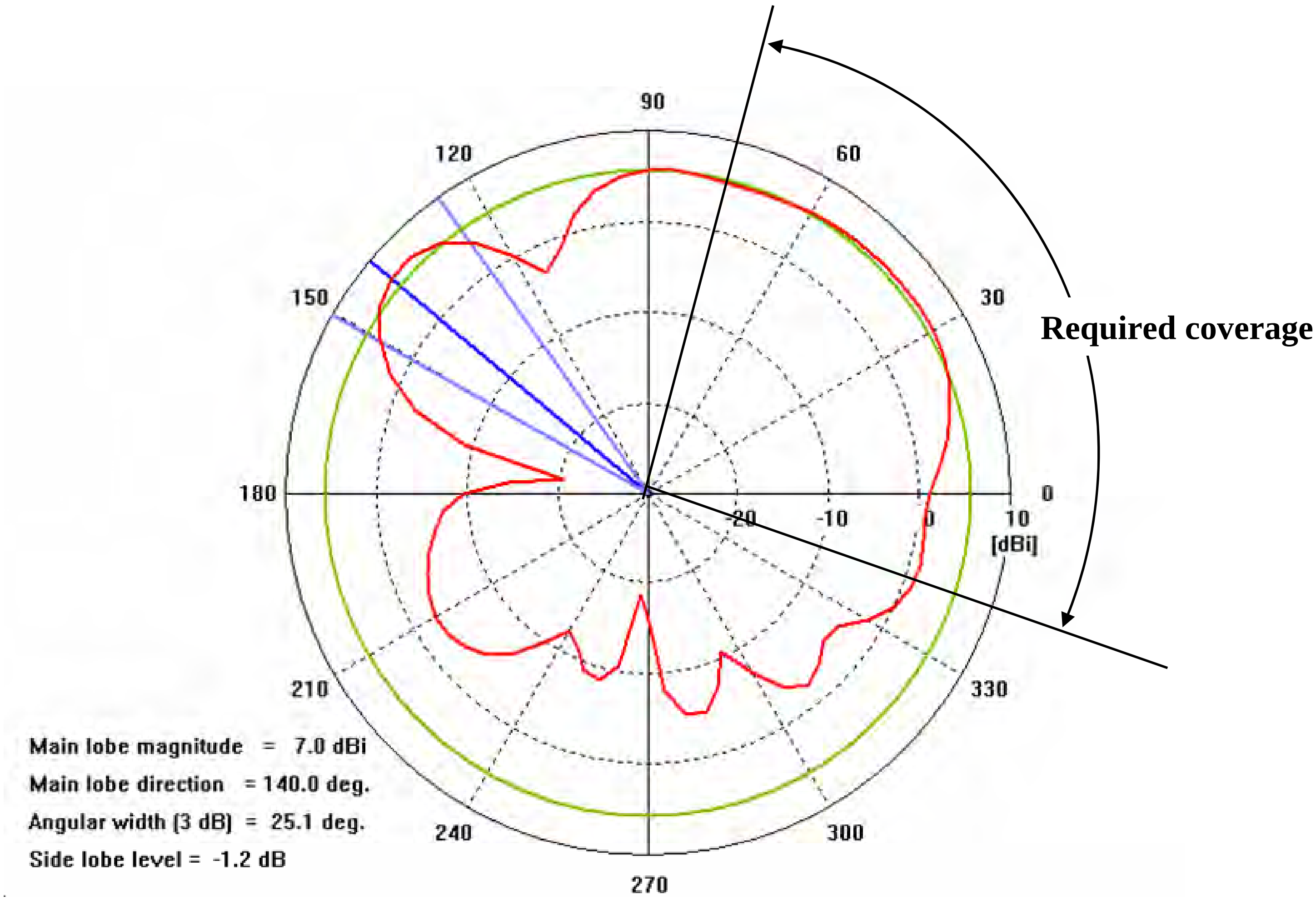
Patch Under Window



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Ceramic Radome To The Rescue!

- Concurrently with KDI/EDC, LM did extensive thermal and mechanical analysis of nose tip
  - Identified proprietary ceramic material that could serve as entire radome/nose tip
    - Will withstand thermal and push-through environments
  - Greatly simplified mounting concerns
    - Back to original concept

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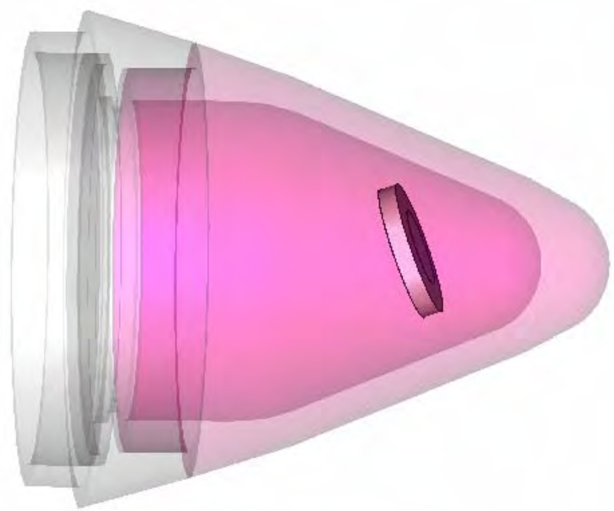
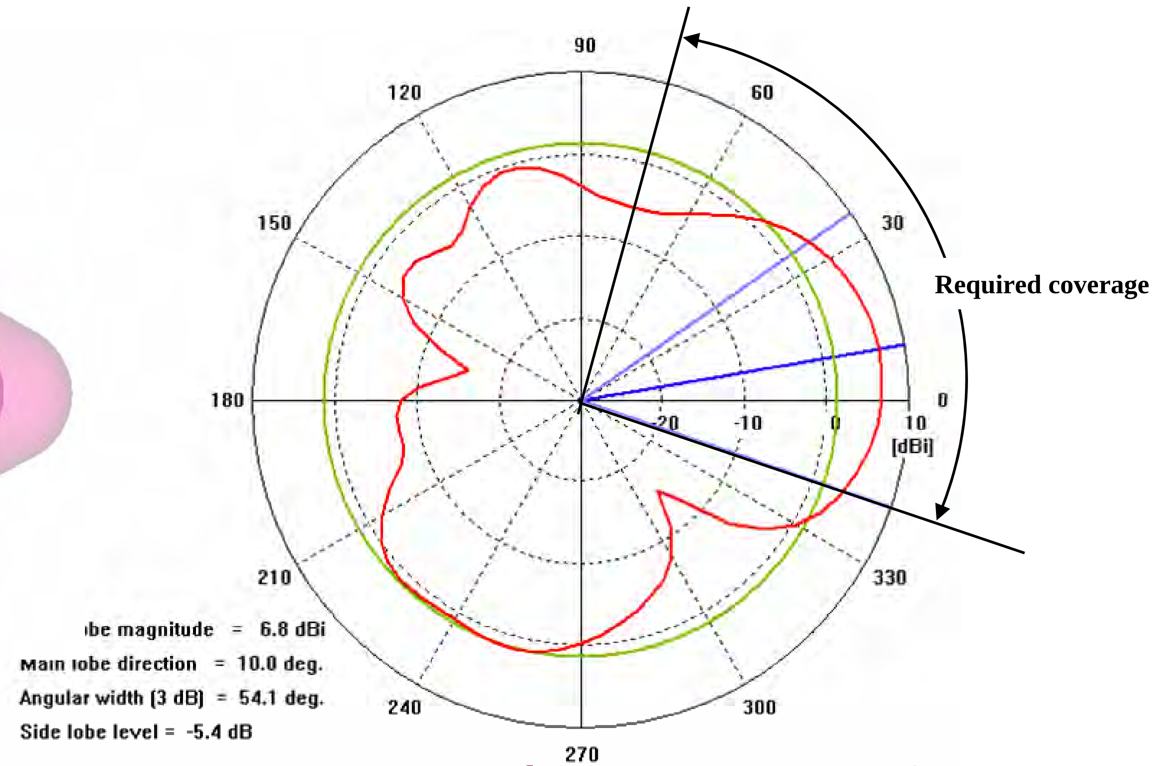
Not So Fast...

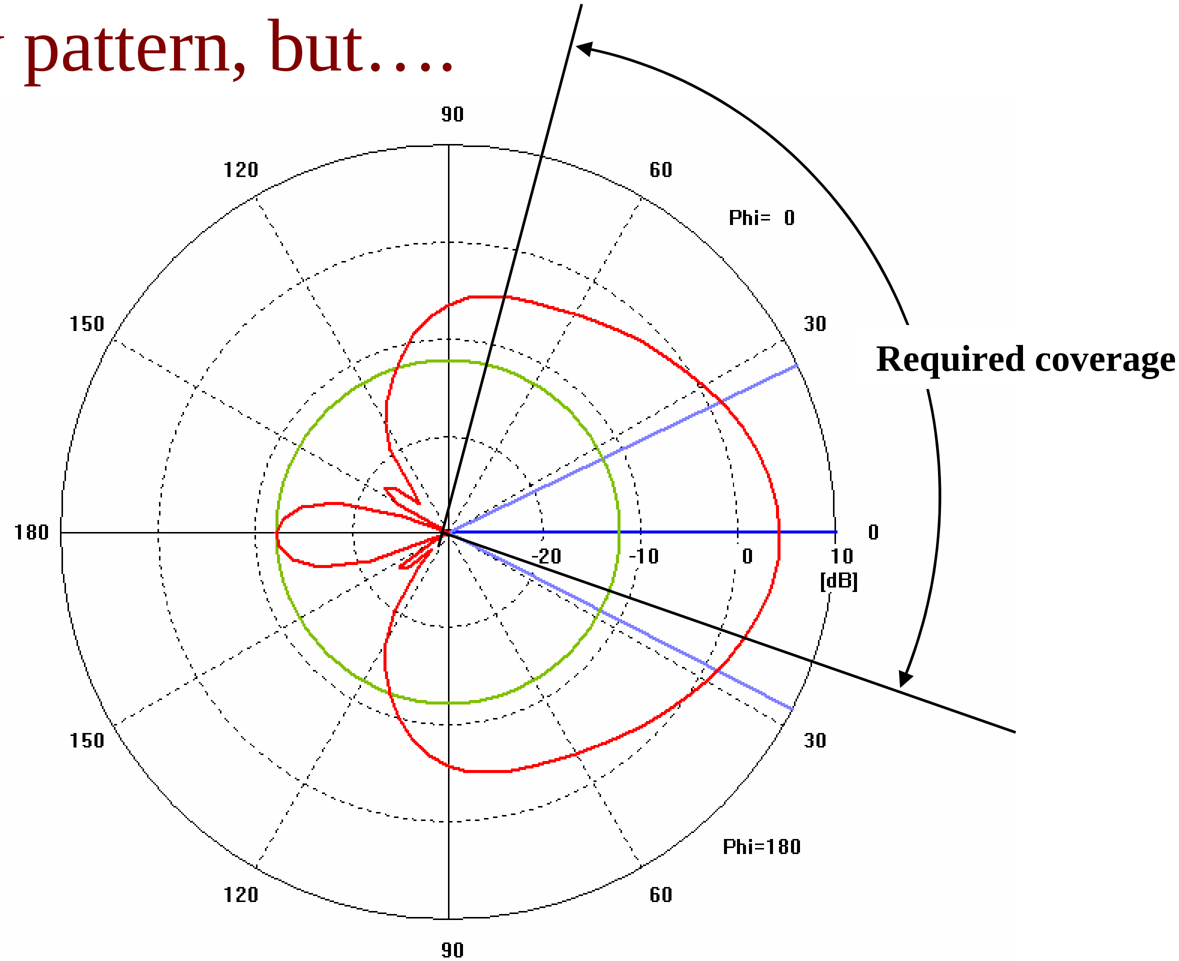
- High dielectric constant had significant influence on pattern (and impedance)
  - Original 20 degree tilt concept didn't work too well





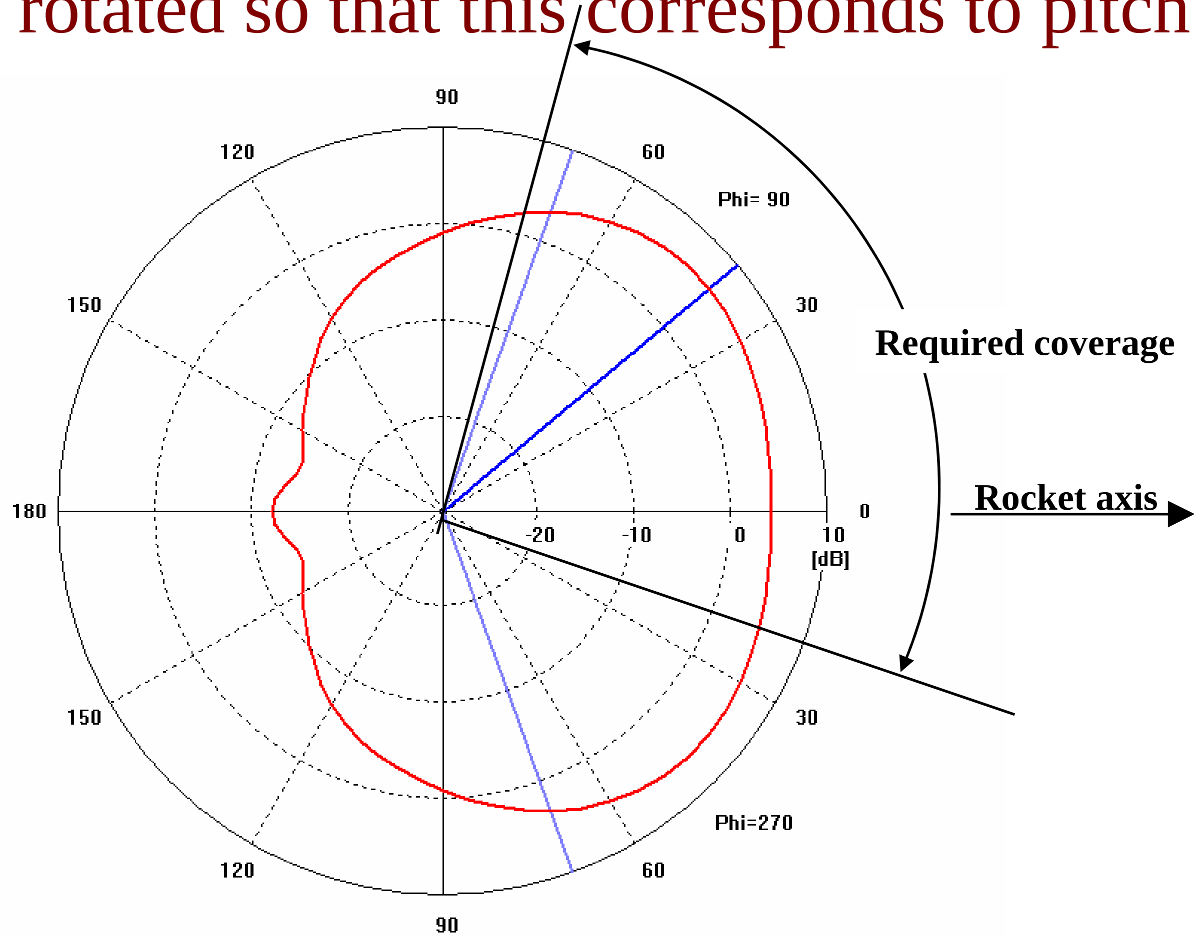
Un-tilted Antenna

- Analyzed un-tilted antenna
  - Very narrow pattern, but….



Un-tilted Antenna

- Horizontal cut
  - Antenna rotated so that this corresponds to pitch plane



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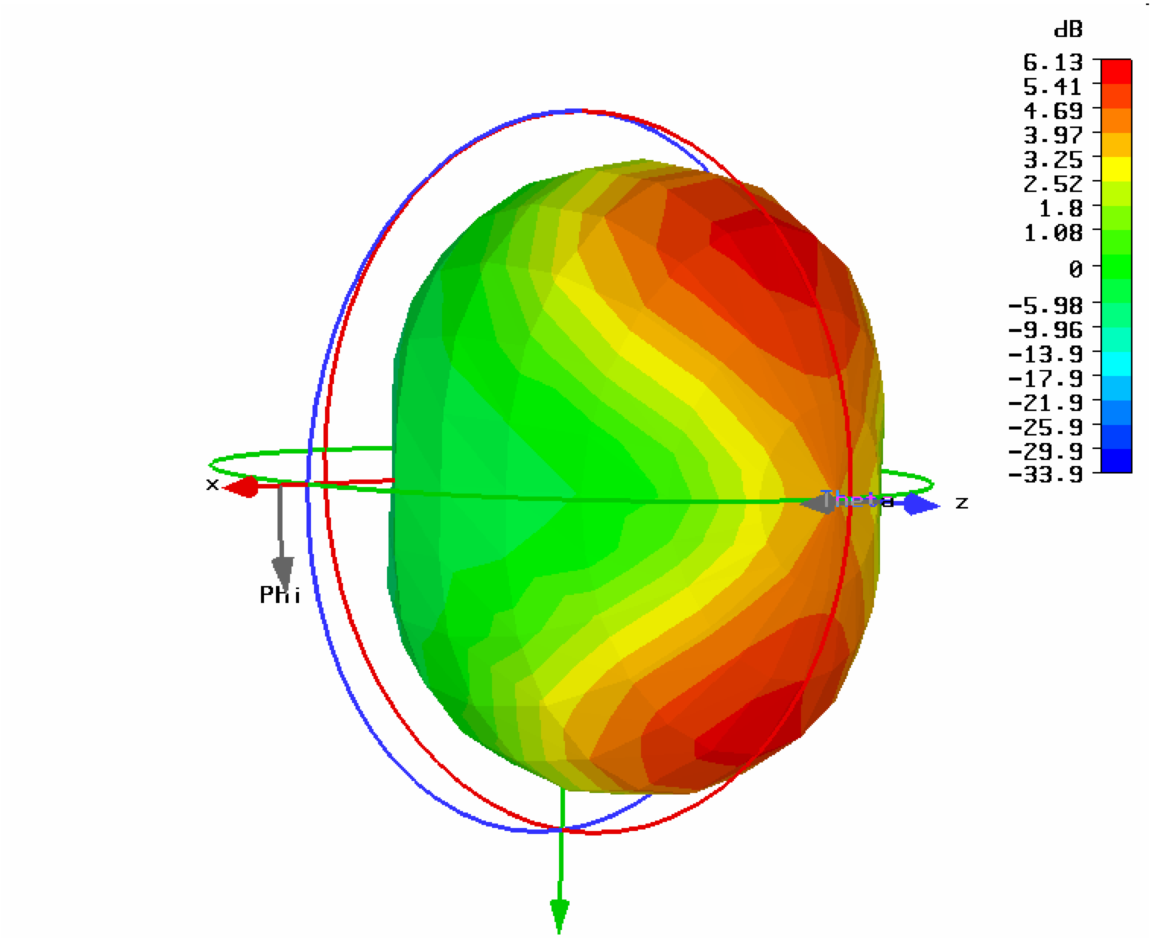
Final Antenna Configuration

- Show figure of 3D pattern



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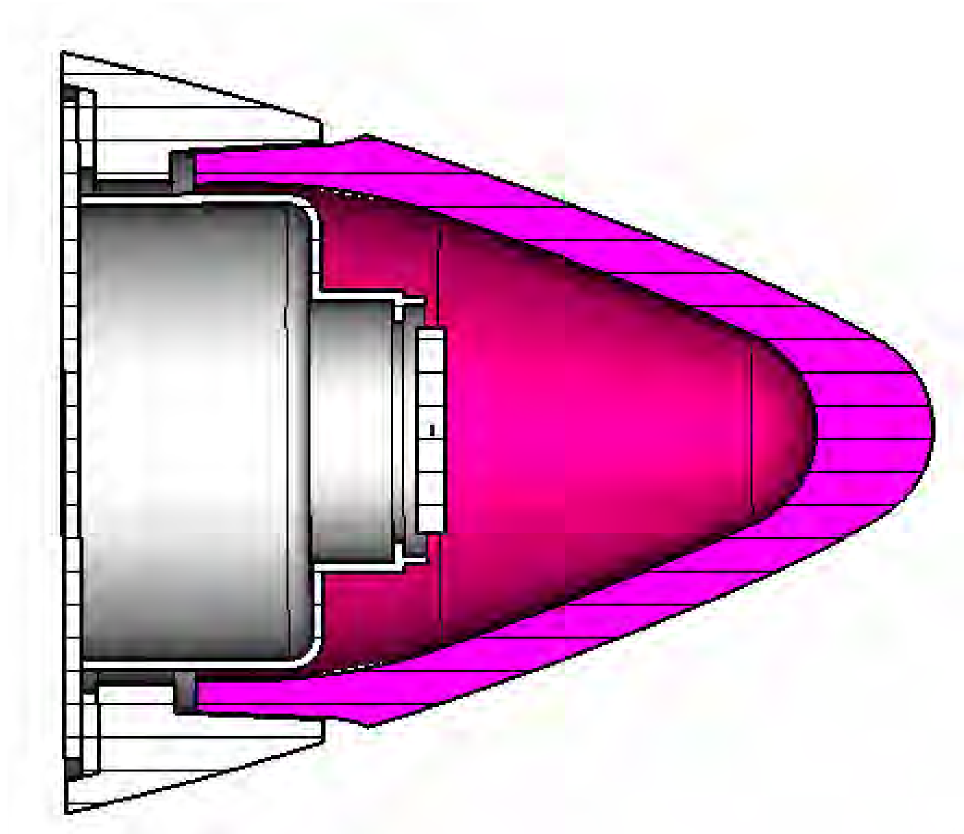
Final Antenna Configuration



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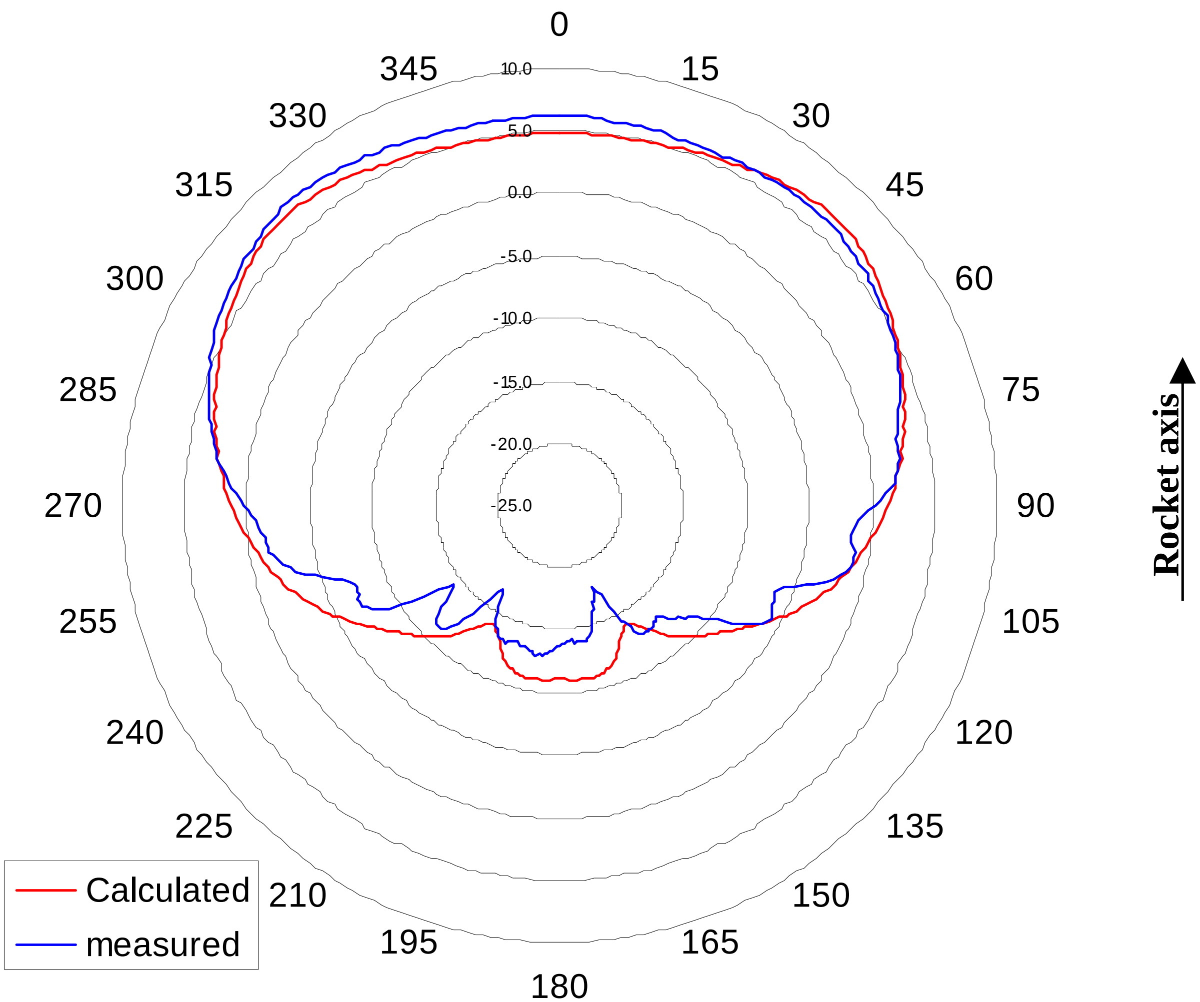
Antenna Performance

Pitch Plane, Measured vs Calculated



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EDC Electronics Development Corporation

Electronics Design
Signal Processor

- Requirements precluded use of existing signal processor
  - High velocities result in Doppler frequencies outside the passband of existing mortar and artillery processing systems
  - Built-in-Test (BIT) not possible with existing processors
  - Aggressive schedule made new ASIC impossible

Electronics Design
Signal Processor

- KDI/EDC leveraged previous IRAD work to design completely new signal processing system
  - All parameters are re-configurable
  - Reports BIT status to ESAF, which reports to Mission Computer
  - All components are commercially available
    - **No custom IC's!**

Electronics Design
Transceiver

- Antenna/Radome design yielded good results, but only at a frequency significantly different than those used on legacy mortar and artillery systems
  - Could not use existing transceivers
  - Aggressive schedule made new MMIC impossible
  - New transceiver designed with commercially available components
    - ☞ **No custom IC's!**

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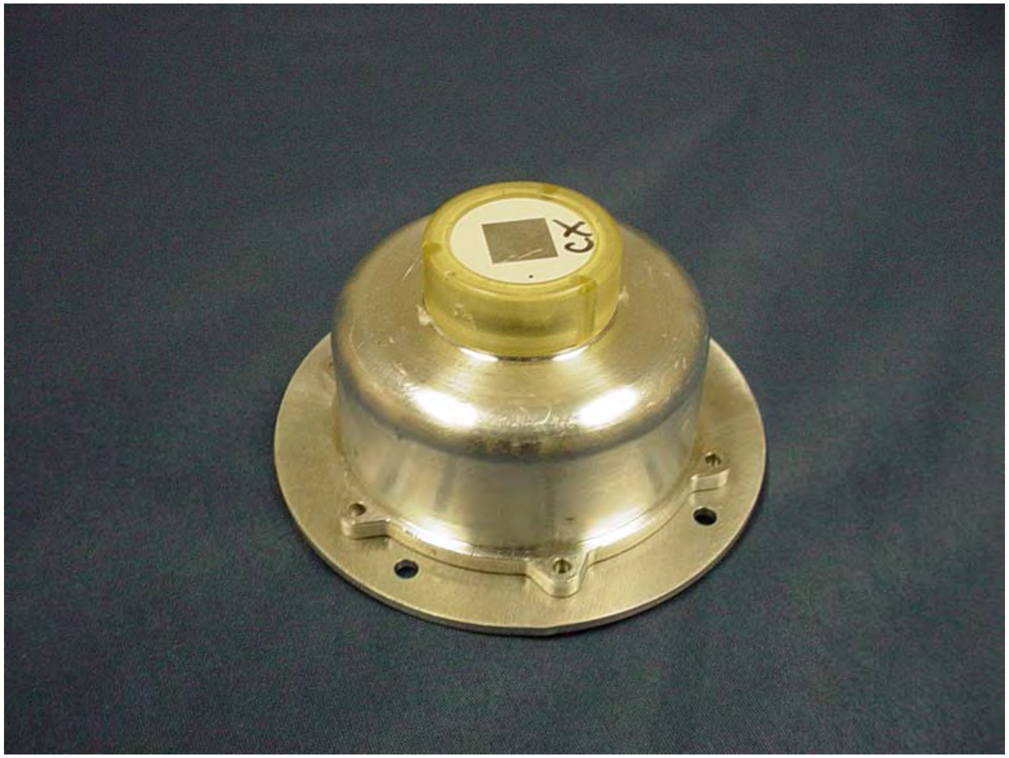
Electronics Assembly



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Summary

- Difficult radome/antenna problem solved through TEAMWORK
  - Concurrent electromagnetic, thermal, and mechanical analysis
- Electronics contains NO custom components
  - Rapid development
  - Versatile design
- First shot success (see next slide)!

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L3 communications
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LOCKHEED MARTIN

EDC
Electronics Development Corporation

KDI Precision Products, Inc.
3975 McMann Road
Cincinnati, Ohio 45245-2395

Affordable Weapon System

ESAF & HOB Design

John Hubert & Brian Miracle

NDIA 50th Annual Fuze Conference

May 9-11, 2006

Proprietary
www.l-3com.com

Affordable Weapon System (AWS) Overview

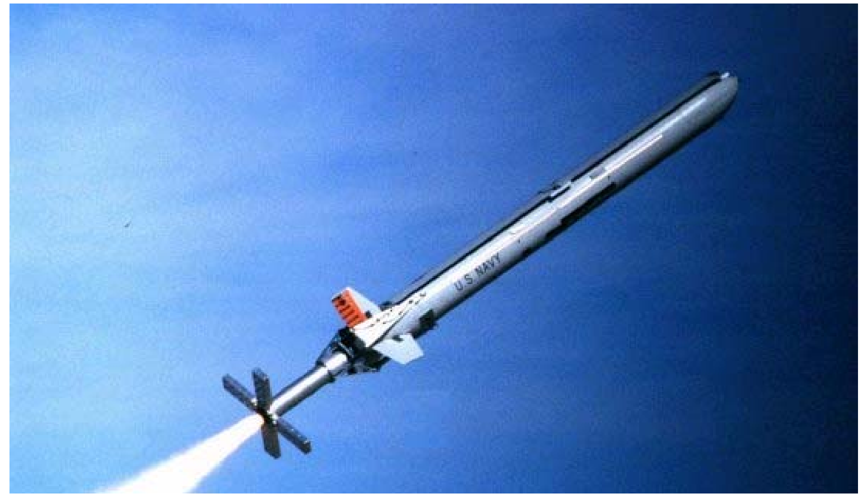
- Program Organization

Naval Surface Warfare Center (Dahlgren, Virginia)
Warhead

- **Titan Corporation**
  - *Missile*
  - *Flight Computer*
  - *Guidance System*
- **KDI Precision Products**
  - *ESAF / HOB Sensor*

Affordable Weapon System (AWS) Overview

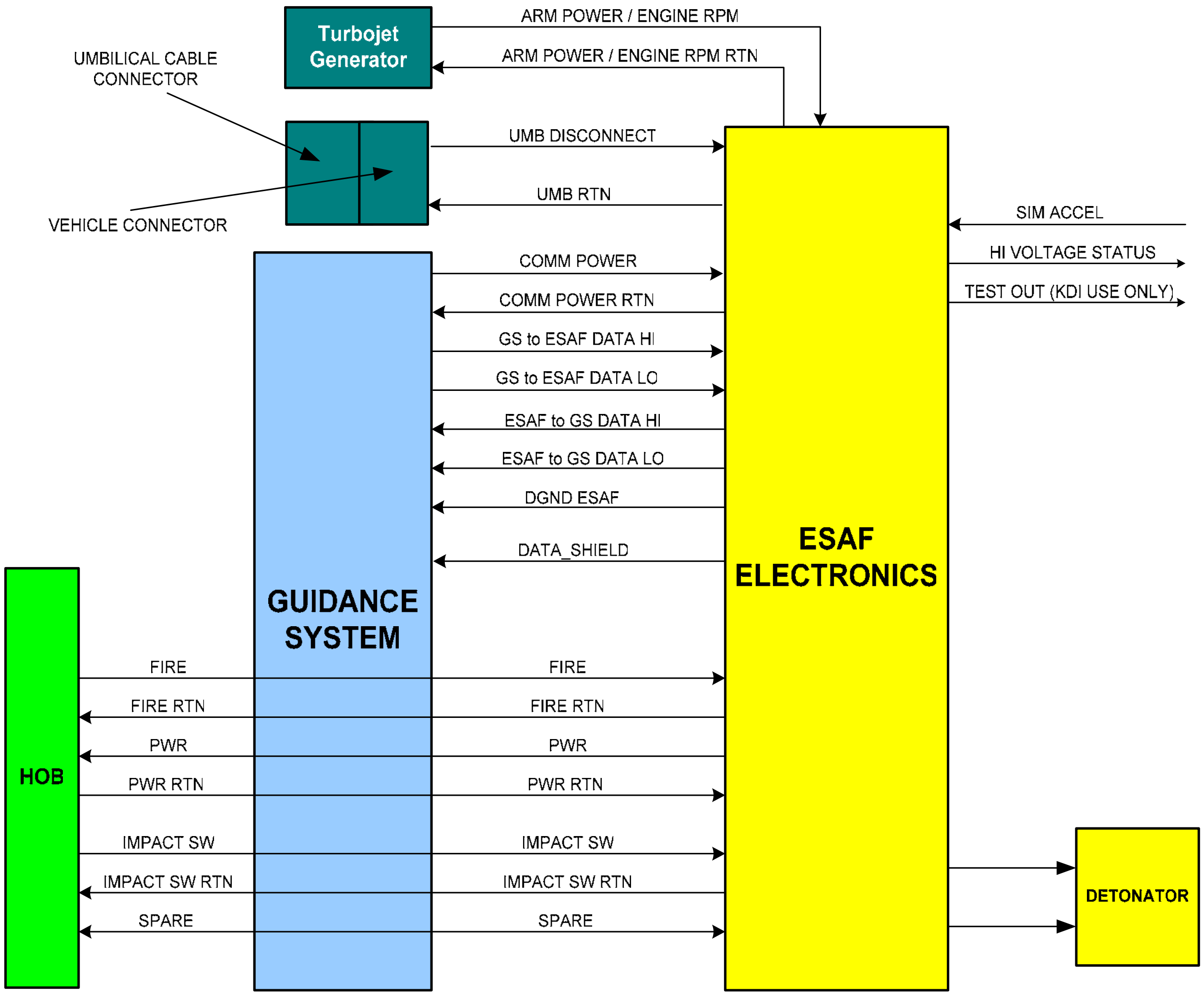
- Features
  - Dimensions:
    - Length: 155 - in
    - Diameter: 13.5 - in
    - Wingspan: 146.4 - in
  - Payload 200 lb
  - Range (T/O): 600 / 840 miles
  - Speed
    - Stall/Max 128/220 knots
    - Cruise 150 knots
  - Endurance (T/O): 4 / 6 hours
  - Accuracy (CEP): ~10 meter
  - Launched from surface ship



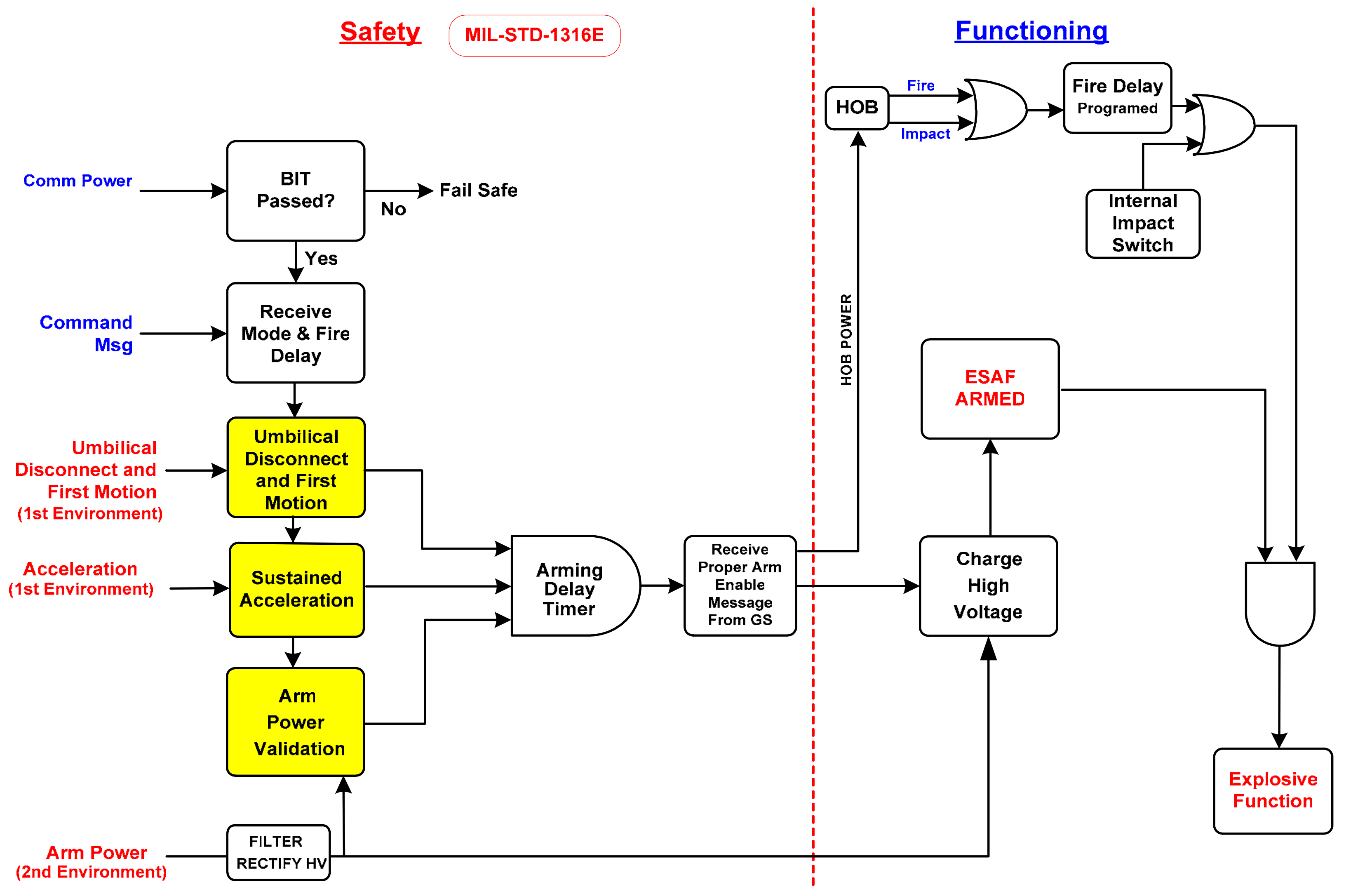
AWS ESAF/HOB Major Design Goals

- ESAF compliant with MIL-STD 1316
- ESAF/HOB to utilize existing technologies to rapidly prototype
- ESAF to initiate with HOB command, HOB impact with target, or ESAF internal impact (backup)
- HOB to initiate warhead at 6 feet above surface or upon impact (primary firing modes)

AWS System Block Diagram

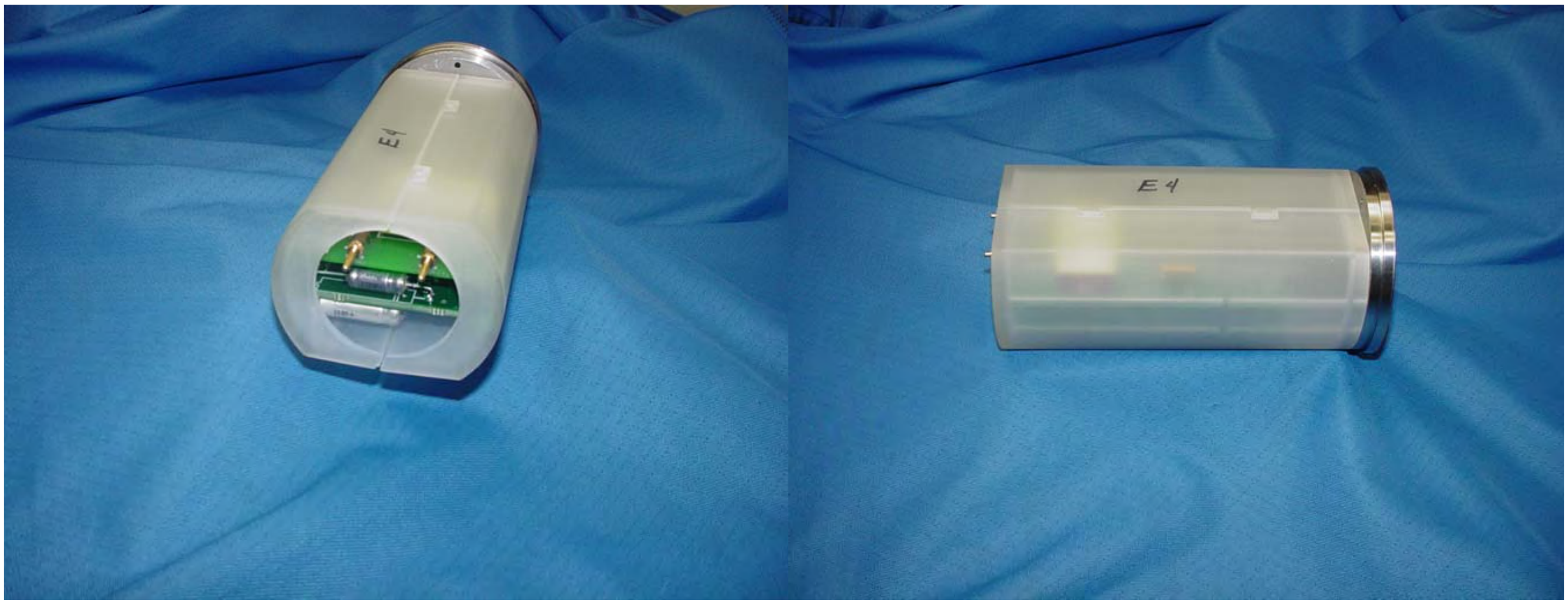


AWS ESAF Functional Block Diagram

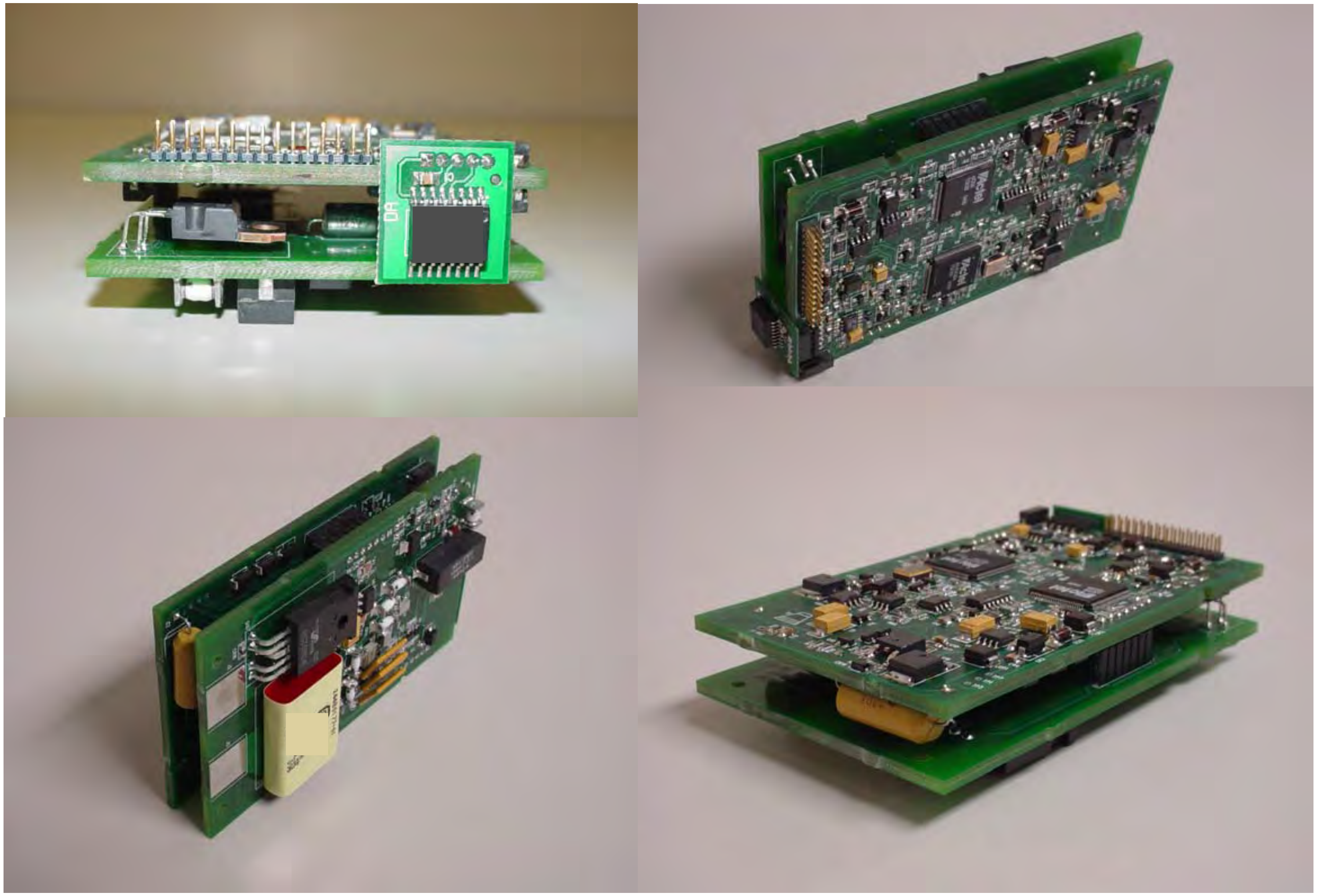


AWS ESAF

AWS ESAF Electronics Assembly



AWS ESAF Circuit Card Assembly



AWS Challenges

- Program
  - Low development budgets
  - Accelerated schedule
- Technical
  - Limited technical specifications at program onset
  - Adapt existing technology to meet program requirements

AWS Program Challenges

- Low development and unit budgets / Accelerated schedule
  - Utilize existing “Off The Shelf” technology
    - Package Form Factor
    - PWB Form Factor / Layout
    - Circuit Architecture
    - Common Parts
  - Risk
    - Low
    - Modifications to existing technology

AWS ESAF/HOB Design Challenges

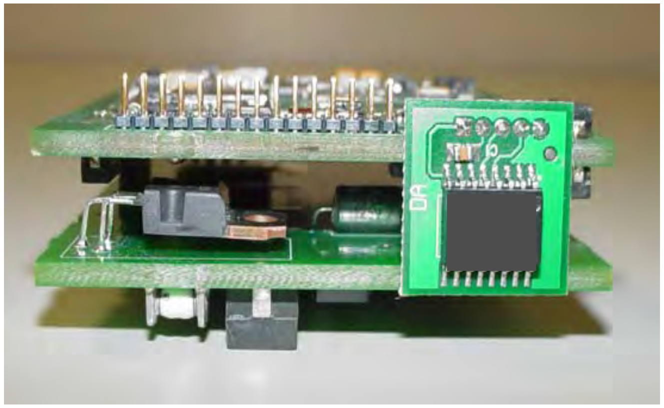
- ESAF
  - Wide arming voltage input range over temperature vs. design target of "off the shelf" design
  - Addition of accelerometer to "off the shelf" design
  - Limited environmental safety signatures (ESAF)
    - Umbilical
    - Acceleration (minimal)
    - Arming Power
- HOB
  - Incorporate impact switch into existing design
  - Input voltage range
  - Packaging
    - Radome shape
    - Interface cabling

AWS ESAF Design Challenge

- Wider and lower arming voltage input range
  - Utilize existing high voltage generation circuit
    - Circuit originally designed for a much higher/regulated voltage over temperature versus the lower and wider voltage range for the AWS.
      - AWS arming power is derived from a turbine generated AC voltage and is rectified to a DC level.
    - Component changes to accommodate wider and lower arming power voltage
    - Dynamic clock optimized to achieve HV regulation within specified time frame

AWS ESAF Design Challenge

- Accelerometer required
  - Low acceleration levels
    - Limits available COTS accelerometers
    - Ship motion may be a significant factor
    - Launch angle offset must be accounted for
  - Packaging/Orientation
    - Addition of small circuit board
    - Limited choice of available devices featuring the acceleration level and orientation required



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KDI Precision Products, Inc.

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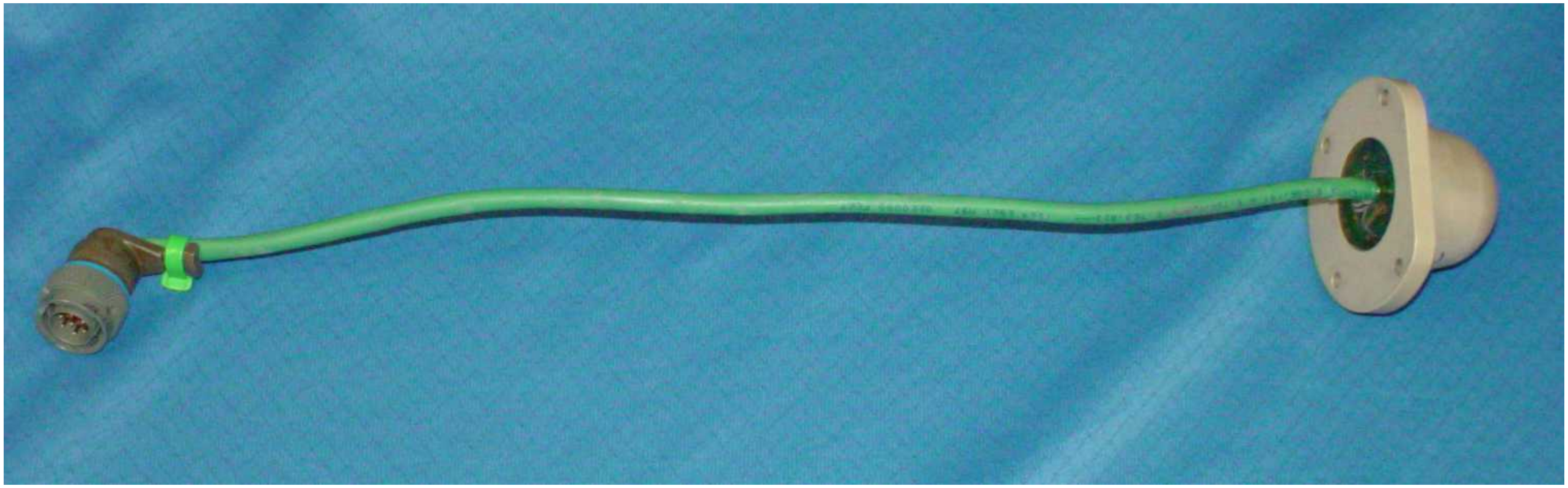
AWS Height of Burst Sensor



AWS Height of Burst Sensor

- Based on DDR proximity detection technology used in the highly successful M734A1 Multi-Option Fuze for Mortars (Over 750,000 units delivered)
- Uses a highly integrated single-chip signal processor
- KDI-designed low-cost transceiver
- Extremely robust patch antenna with integrated transceiver circuitry

AWS HOB Design Challenges

- Incorporate impact switch into design
- Modify mechanical package to interface with AWS nose section
- PWB and cable modification to provide required signals
- Cabling and connector to meet space constraints
- Modification of design to meet lower input voltage requirement

AWS HOB Design Challenges

- Impact switch required
  - Picked existing normally closed impact switch used on other programs.
  - Mounted between power and processor PWBs

- Modify mechanical package to interface with AWS nose section
  - Modified existing Ogive radome to current design

AWS HOB Design Challenges

- PWB and Cable Modification to Provide Required Signals
  - Modified power PWB to provide additional signals, including interface to impact switch
  - Selected off the shelf cable to incorporate additional signals
- Cabling and Connector to Meet Space Constraints
  - HOB cable interfaces to AWS Using MS27473 Plug with 90 degree backshell that meets limited space requirements between missile wall and socket.

AWS HOB Design Challenge

- Modification of Design to Meet Lower Input Voltage Requirement
  - Lowered series resistance value on power board
  - Meets input voltage range of 8 ± 1VDC across temperature range of -40 to +70 °C.

AWS HOB Design Test Results

- Current design meets height of burst requirement of 6 ± 3 feet at reflection coefficients ranging from 0.2 to 0.8 and temperatures ranging from -40°C to +70°C.
- Functions acceptably after exposure to AWS in-flight environments.

AWS HOB Design Test Results

AWS ESAF/HOB Program Status

- ESAF
  - Breadboard unit delivered for system integration
  - First design iteration successfully tested for explosive output after exposure to AWS in-flight environments
  - Delivered Inert and Live prototype units for test purposes
  - Second design iteration started
    - Construction Of IM and Test units started

- HOB
  - Successful height of burst shot with flash charge
  - Delivered prototype units for testing purposes

Conclusion

- KDI successfully provided a timely and cost effective solution for the AWS program by:
  - Adapting a common and proven 3” architecture/form factor
  - Adapting a proven, high volume, HOB design
  - Closely working with the customer
    - Regularly scheduled meetings
    - Written status reports by program management
  - State of the art manufacturing

50th Annual Fuze Conference

Wednesday, May 10

- Session III-A (Chair: Mr. Eric Roach)
  - 1:00 PGMM, New Application for an Existing Fuze
  - 1:20 Proximity Sensor for the GMLRS
  - 1:40 Multifunction Programmable Fuze 260MF
  - 2:00 Portable Excalibur Fire Control System
  - 2:20 Enhanced Portable Inductive Artillery Fuze Setter
  - 2:40 Air Burst Munitions for Cannon Caliber Applications
  - 3:00 BREAK
  - 3:20 Evolution of DSU-33 C/B Proximity Sensor
  - 3:40 FY06 Foreign Comparative Test of PIMPF
  - 4:00 Dev & Qual of programmable Fuze for MK285
  - 4:20 A New Fuze for an Electromagnetic Gun
  - 4:40 Intro of MOFA DM84 on 120mm Rifled Mortar
  - 5:00 TBD

50th Annual Fuze Conference

Thursday, May 11

- Session IV-A (Chair: Dave Lawson)
  - 8:00 Enhancing Dispenser System Function…
  - 8:20 Challenges Assoc. w/Development of Afford…
  - 8:40 FMU-139C/B Electronic Bomb Fuze Design
  - 9:00 Shipboard Submunition Fuze Safety & Relia…
  - 9:20 TBD
  - 9:40 Thermal Battery Development-Reduced Varia..
  - 10:00 BREAK
  - 10:20 Guidance Integrated Fuze (GIF)
  - 10:40 GIF: Dev & Test of a Roll Control Joint
  - 11:00 Perf. Testing of Lead-Free Stab Detonators
  - 11:20 TNO Research on EFIs in Relation to IM
  - 11:40 LUNCH

Shipboard Submunition Fuze Safety and Reliability Improvement

John Kunstmann
NSWC IH Code E314F
Kunstmannjf@ih.navy.mil
(301) 744-1190

Shipboard Submunition Fuze Safety and Reliability Enhancement

- Sponsored by ONR 353
- Outgrowth of FY04 effort:

  Assessment of Technologies for USMC HIMARS Submunition Fuze Design

- Evolved Into Broad Based Multi-Year Technology Effort Looking at all Applicable Munitions

Shipboard Submunition Fuze
Safety and Reliability Enhancement

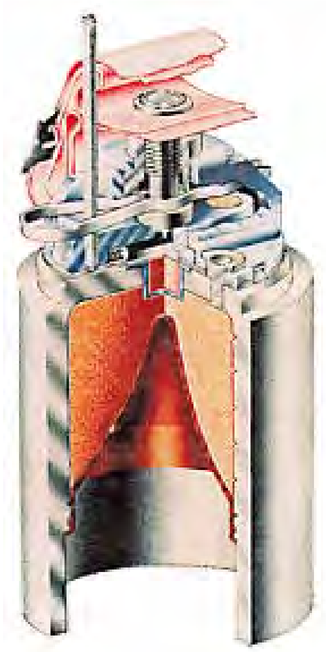
- ISSUE - A number of existing, widely used submunitions do not currently meet either the Navy WSESRB established shipboard safety requirement or the SECDEF policy for Submunition Reliability.

- A low-cost solution is needed to both allow submunitions to be safe enough to be used in future shipboard carried weapons systems and reliable enough to be employed in the field.

DRIVING FACTORS

- **OSD** Policy: field future submunitions with a 99% or higher functioning rate*

- **WSESRB** Position: Shipboard Submunitions must have a probability of less then one in a million for either of the following cases:
  – Arming when inadvertently dispensed from the munition.
  – Inadvertently being dispensed from the munition.**



* SECDEF Memorandum, 10 JAN 2001
Subj: DoD Policy on Submunition Reliability (U)

** NAVSEASYSCOM Letter 8020 Ser N314-H-22-001/373, 28 APR 04

Subj: WEAPON SYSTEM EXPLOSIVES SAFETY REVIEW BOARD EXECUTIVE SESSION MEETING ON SAFETY REQUIREMENTS FOR WEAPONS CONTAINING SUBMUNITIONS

Safety and Reliability

- Current Army efforts focus on adding Self-Destruct Feature to existing fuze structure to meet 99% functional reliability.
- This approach "places the ship at increased risk since the submunitions will now be designed to reliably function regardless of how they are expelled from the carrier munition, intentionally or inadvertently."*

*NAVSEASYSCOM Letter 8020 Ser N314-H-22-001/373, 28 APR 04

Subj: WEAPON SYSTEM EXPLOSIVES SAFETY REVIEW BOARD EXECUTIVE SESSION MEETING ON SAFETY REQUIREMENTS FOR WEAPONS CONTAINING SUBMUNITIONS

Safety and Reliability

Safety is related to the ability to prevent undesired hazardous events. Safety is typically quantified as rate of Failure:

e.g. Failure of 1 in $1x10^6 = 1/10^6 = 1 \times 10^{-6}$

Safety can also be expressed as Safety-Related Reliability:

e.g. $R_S = 1 – F = (1- 1 \times 10^{-6}) = .999999$

Reliability commonly refers to the ability to perform the desired function at the desired time, i.e. Functional Reliability. Typically quantified as rate of Function:

e.g. Function of 99 out of 100 = 99/100 = .99

Safety and Reliability
Change Through Design

Safety and Reliability can be altered by:

- Fault Avoidance - Keep Problems from Occurring
  - Component Quality
- Fault Tolerance – Some Problems OK
  - Component Redundancy

Safety and Reliability
Change Through Design

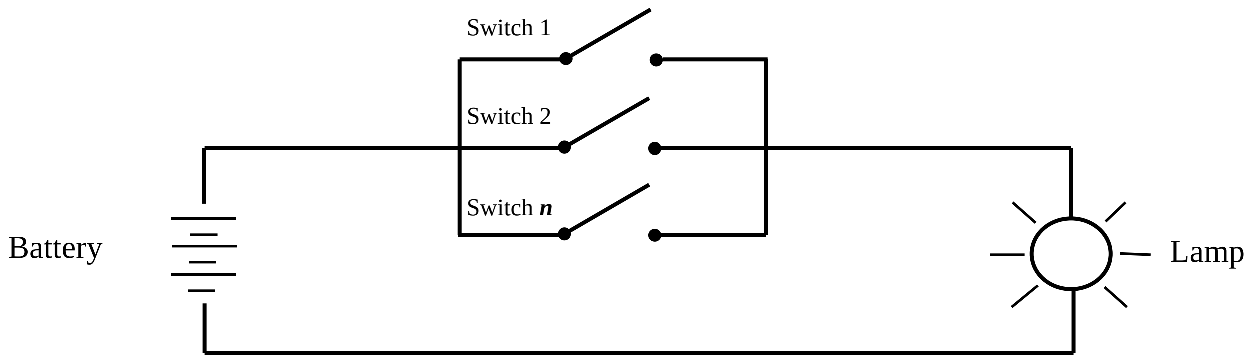
Fault Avoidance:

High Quality Components = Fewer Problems

- Quality can be hard to quantify (what makes a part "better" in a given situation)
- Higher quality typically means higher cost
- Very high quality can be hard to achieve and demonstrate

Safety and Reliability
Change Through Design

Reliability Related Fault Tolerance: Parallel Components



$$P_p = 1-\prod_{i=1}^{n} (1-P_i)$$

where,

P_p = the probability of event in the parallel system
P_i = the probability of the event in the subsystem
n = the number of subsystems

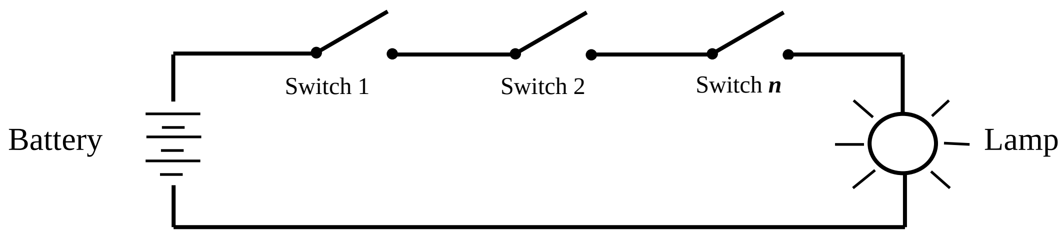
Example:if probability of an event for a component is 1 in 10 (10%) the system probability for 3 of these components in parallel would be:

$$\mathbf{P_p = 1\text{-}(1\text{-}0.1)(1\text{-}0.1)(1\text{-}0.1) = 0.271 \text{ or } 27.1\%}$$

Parallel Systems Increase Event Probability

Safety and Reliability
Change Through Design

Safety Related Fault Tolerance: Series Components



$$P_s = \prod_{i=1}^{n} P_i$$

where,

P_s = the probability of event in the series system
P_i = the probability of the event in the subsystem
n = the number of subsystems

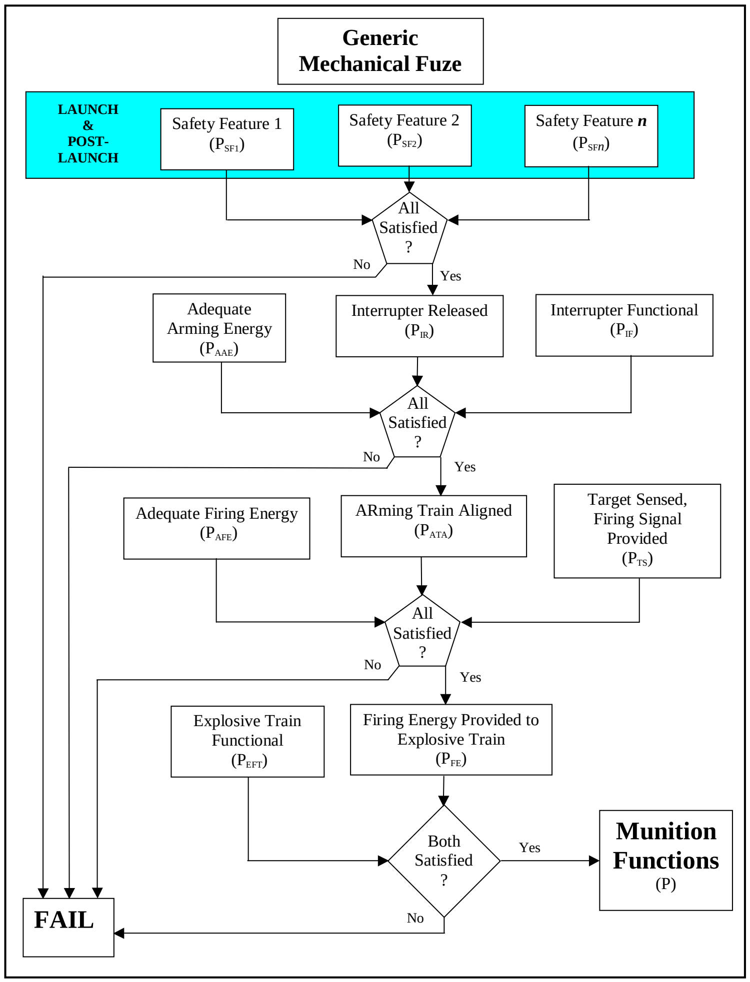
Example: if probability of an event for a component is 1 in 10 (10%) the system probability for 3 of these components in series would be:

P_s = (0.1)(0.1)(0.1) = 0.001 or 0.1%

Series Systems Decrease Event Probability

Safety and Reliability

Generic Fuze Functional Reliability



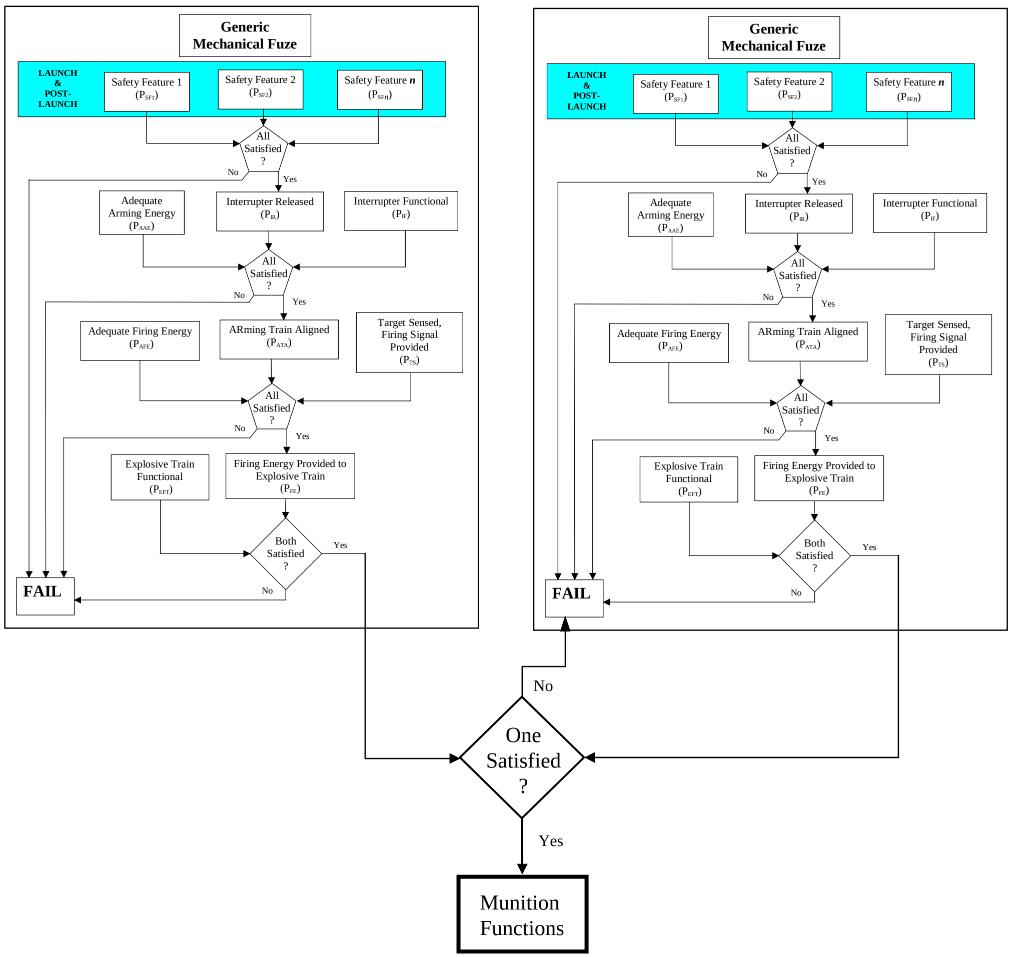
With single fuze

$$\begin{aligned} P &= (P_{fe})(P_{eft}) \\ &= ((P_{ata})(P_{afe})(P_{ts}))(P_{eft}) \\ &=(((P_{ir})(P_{aae})(P_{if}))(P_{afe})(P_{ts}))(P_{eft}) \\ &=((((P_{sf1})(P_{sf2})(P_{sfn}))(P_{aae})(P_{if}))(P_{afe})(P_{ts}))(P_{eft}) \end{aligned}$$

Required Submunition Reliability ≥ 99%

Safety and Reliability

Generic Fuze Functional Reliability



With 2 parallel fuzes

$$P = 1-(1-P_{FA1})(1-P_{FA2})$$

P = Probability of Munition Function
P_{FA1} = Probability of Fuze 1 Function
P_{FA2} = Probability of Fuze 2 Function

Assuming that the fuzes have equal probability of arming ($P_{FA1} = P_{FA2}$), and **$P \geq$ 99%** to meet the OSD requirement, then the equation reduces to:

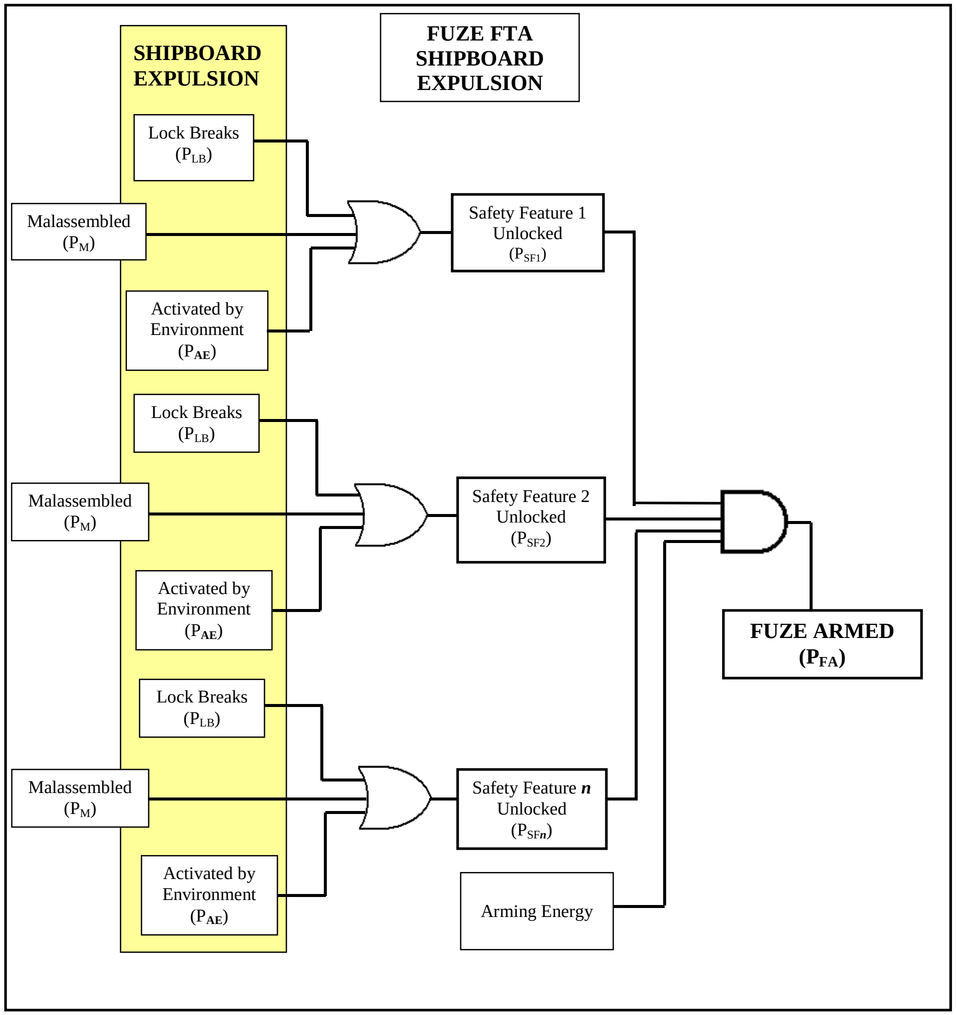
$P = 1-(1-P_{FA1})(1-P_{FA1})$
$P = 1-(1-P_{FA1})^2$
$P = 1-(1-2P_{FA1} + (P_{FA1})^2)$
$P = 2P_{FA1} - (P_{FA1})^2$
$0 = 0.99 - 2P_{FA1} + (P_{FA1})^2$

Solving the quadratic yields

$$\mathbf{P_{FA1} \geq 90\%}$$

Safety and Reliability

Generic Fuze Safety



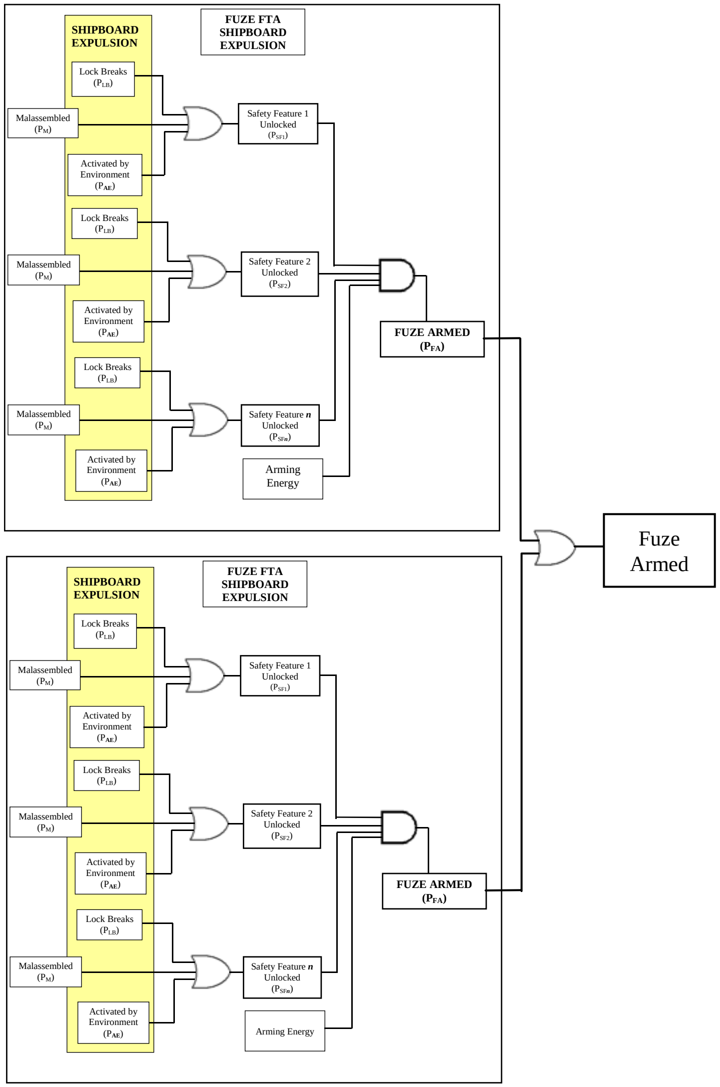
With single fuze

$P_{FA} = (P_{SF1})(P_{SF2})(P_{SF\boldsymbol{n}})$

$P_{FA} \leq 1 \times 10^{-6}$

Safety and Reliability

Generic Fuze Safety



With 2 parallel fuzes

$$P = 1- (1-P_{FA1})(1- P_{FA2})$$

P = Probability of Either Fuze Arming
P_{FA1} = Probability of Fuze 1 Arming
P_{FA2} = Probability of Fuze 2 Arming

Assuming that the fuzes have equal probability of arming ($P_{FA1}= P_{FA2}$), and $\mathbf{P_{FA} \leq 1 \times 10^{-6}}$ to meet the WSESRB requirement, then the equation reduces to:

$$P_{FA} = 1- (1-P_{FA1})(1- P_{FA1})$$

$$P_{FA} = 1- (1-P_{FA1})^2$$

$$P_{FA} = 1- 1+ 2P_{FA1} - (P_{FA1})^2$$

$$0 = P_{FA} - 2P_{FA1} + (P_{FA1})^2$$

$$0 = \mathbf{1 \times 10^{-6}} - 2P_{FA1} + (P_{FA1})^2$$

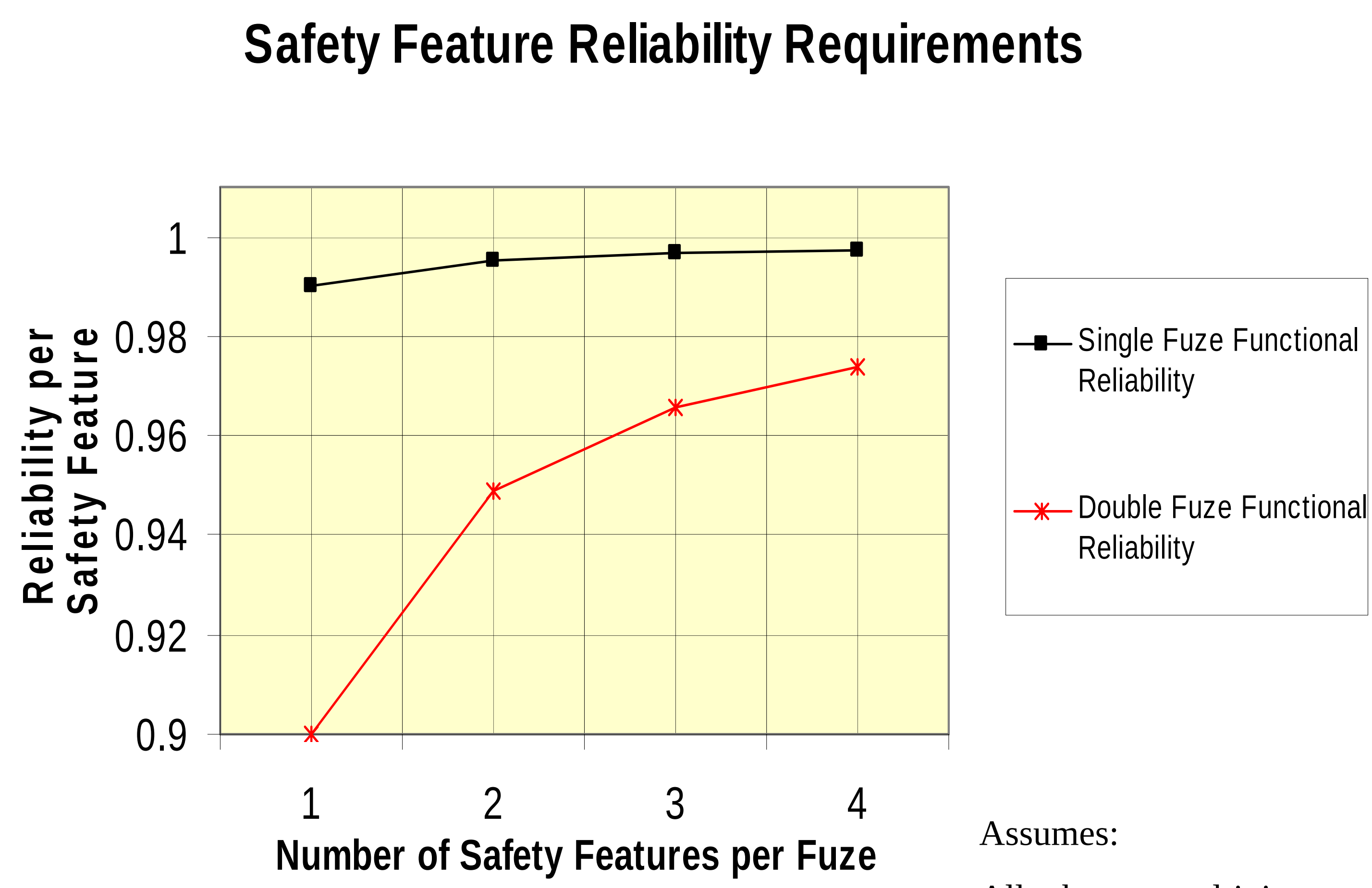
$$\mathbf{P_{FA1} = 5 \times 10^{-7}}$$

Or less then 1 in 2 million

Safety and Reliability

Number of Safety Features		Functional Reliability Requirements per Individual Safety Feature			Safety-Related Reliability Requirements per Individual Safety Feature	
		Single Fuze	Dual Fuze		Single Fuze	Dual Fuze
1		0.99	0.9		0.999999	0.9999995
2		0.994987437	0.9486833		0.999	0.9992929
3		0.996655493	0.9654894		0.99	0.992063
4		0.99749057	0.9740037		0.968377223	0.9734085
5		0.997991952	0.9791484		0.936904266	0.945072

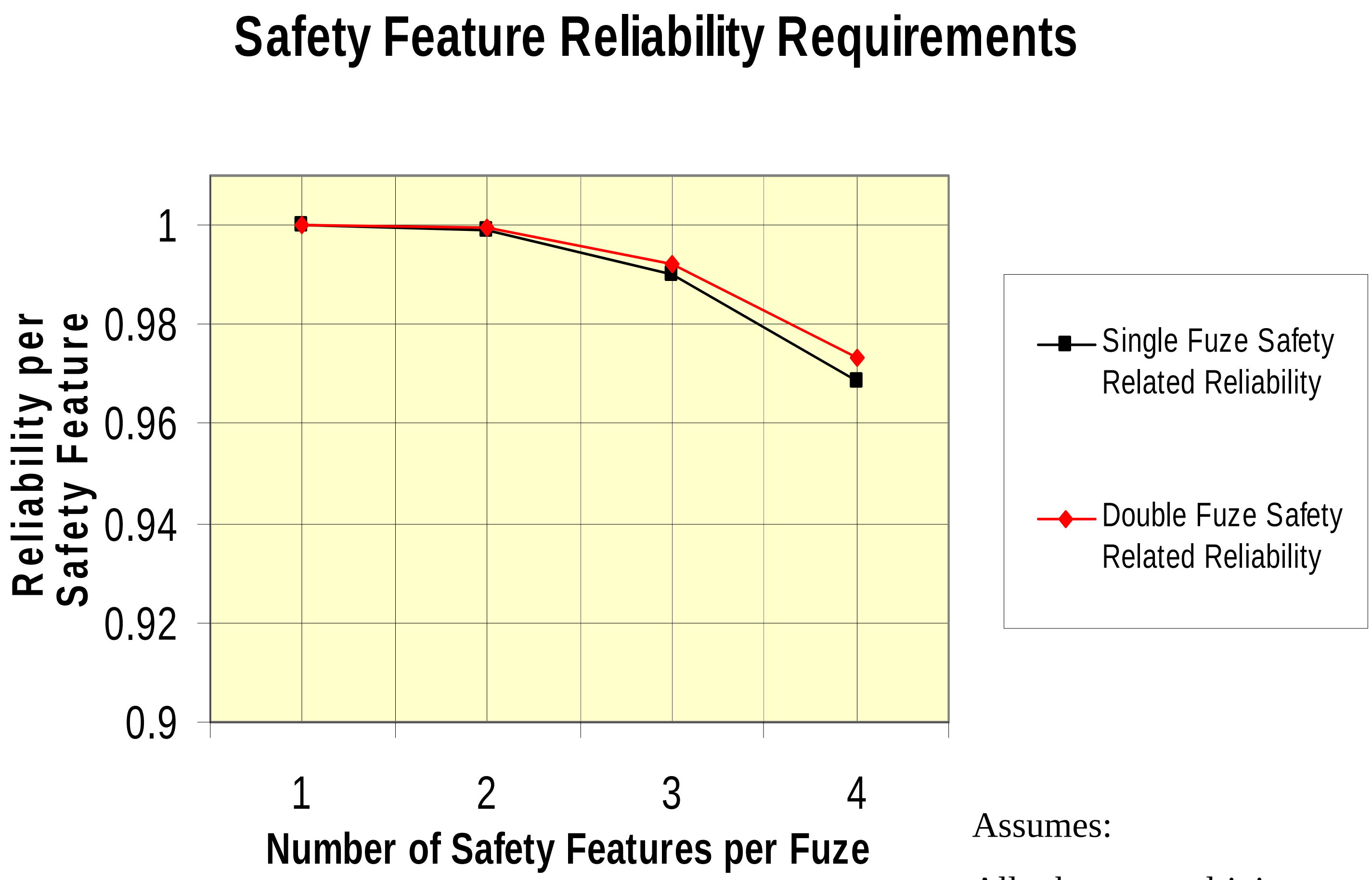
Safety and Reliability



Assumes:

All other event driving probabilities = 1

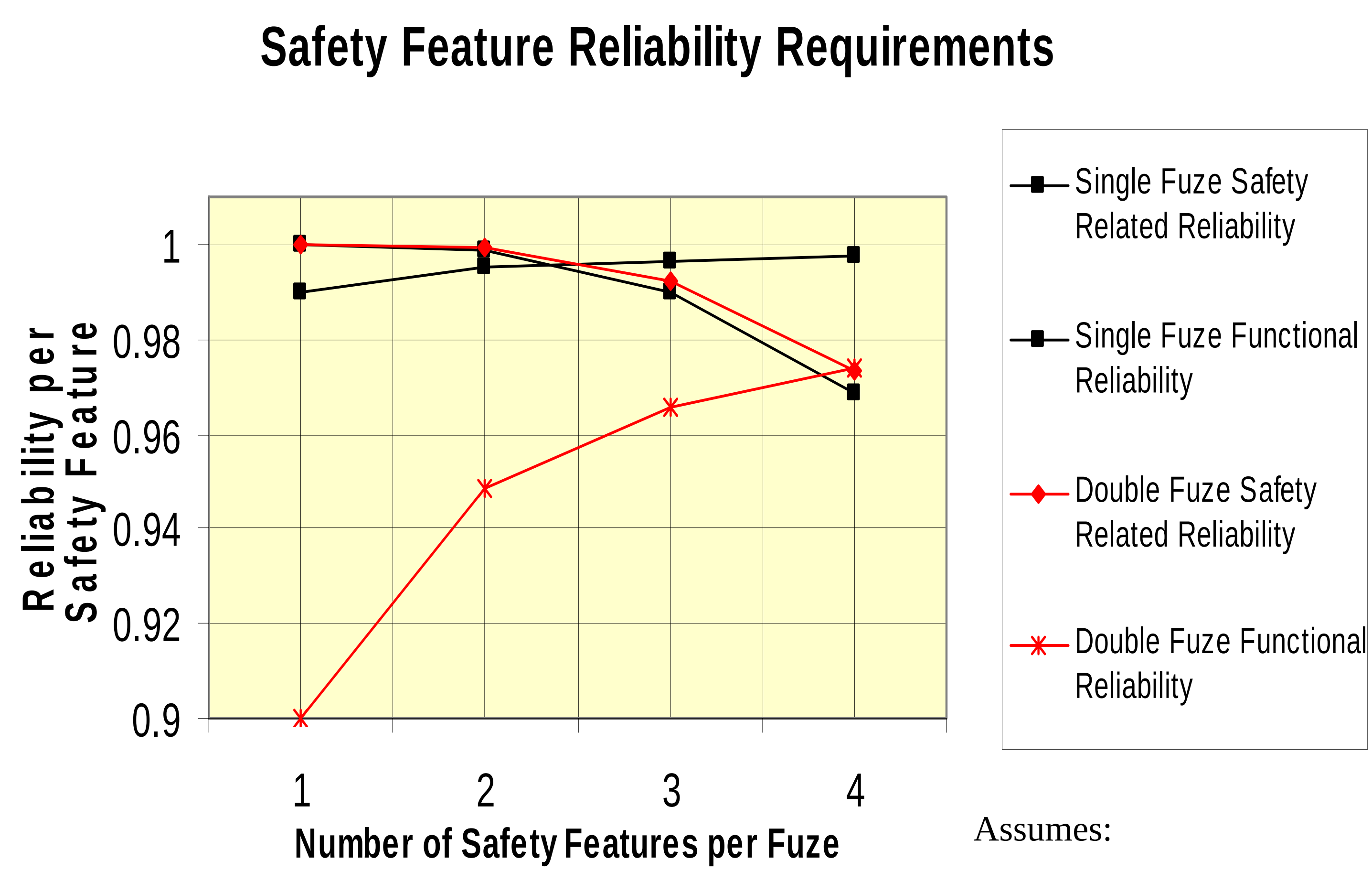
Safety and Reliability



Assumes:

All other event driving probabilities = 1

Safety and Reliability



Assumes:

All other event driving probabilities = 1

Safety and Reliability

Using two parallel fuzes each with three safety features in series allows meeting of the reliability and safety requirements using components having more easily obtainable reliability.

MEMS as a Means to Achieve Dual Fuzing

- Readily manufactured at numerous commercial facilities.
- At the chip level there is no assembly required regardless of the number of features.
- Much like photocopying, increasing MEMS features does not significantly affect cost.

ABC

Costs about the same as


XXVI.

Grosse Brenn-nessel. Urtica urens, major.

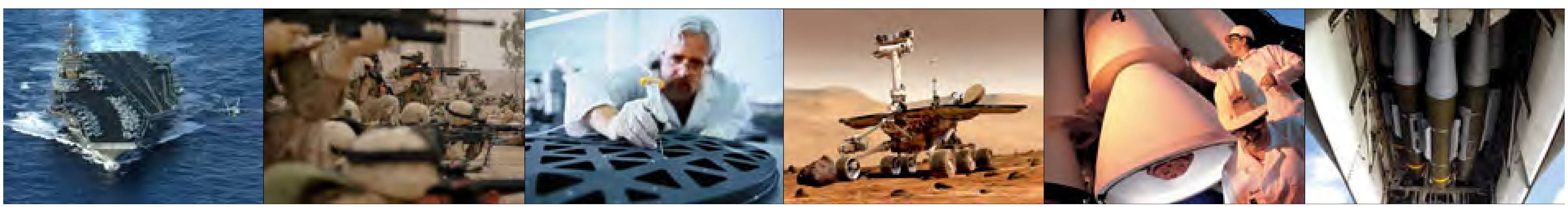
FMU-139C/B Electronic Bomb Fuze Design Update

Thursday, May 11, 2006

David Liberatore
ATK Tactical Systems
(304)726-7587

50th Annual
NDIA Fuze Conference
Norfolk, VA

Distribution Statement A approved for public release; distribution is unlimited.



Agenda

An advanced weapon and space systems company

FMU-139 Description

FMU-139 Background

ATK FMU-139B/B History

FMU-139C/B Design

- Requirements
- Design Approach
- Results
- Status

Questions?

Distribution Statement A approved for public release; distribution is unlimited.

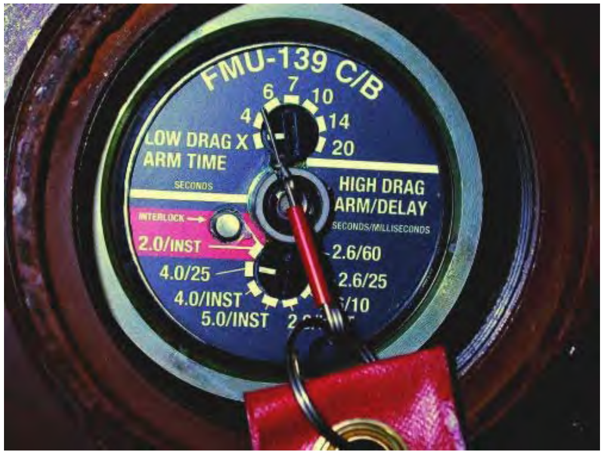
FMU-139 Description

ATK

An advanced weapon and space systems company

General-Purpose, Electro-Mechanical Bomb Fuze

- Joint-service fuze (NAVAIR PMA-201 is lead service)
- Used with M117 and MK80 GP warheads, incl. JDAM and Paveway
- Out-of-line, rotor-based safing and arming

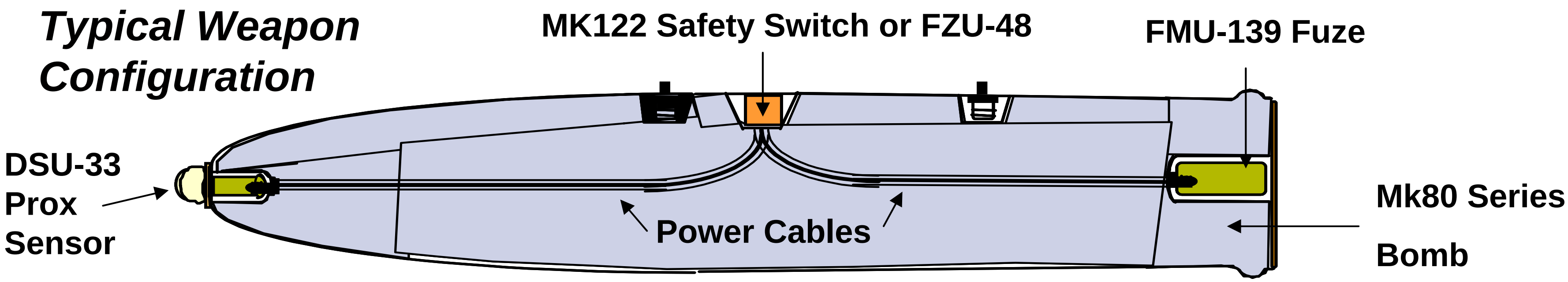


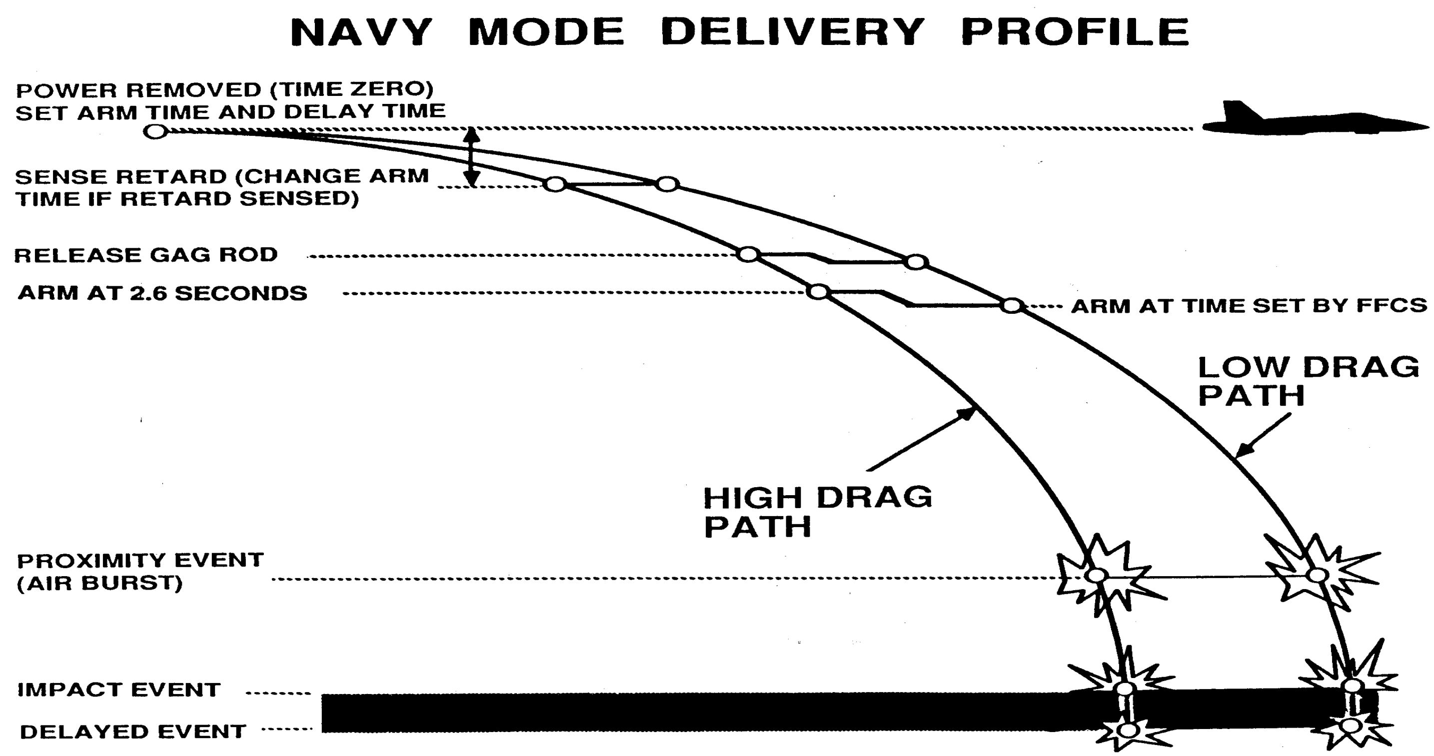
Versatile, Multi-Mode Performance

- Selectable arm times: 2 to 20 seconds
- Impact, proximity, or delay detonation settings
- Powered by FZU-48 Initiator (USAF) or FFCS energy burst (USN)
- Offers limited cockpit programmability in FFCS mode
- Capable of high or low drag delivery; auto-detects drag conditions

FMU-139 Description (cont'd)

An advanced weapon and space systems company





Distribution Statement A approved for public release; distribution is unlimited.

FMU-139 Background

FMU-139/B development completed in 1980’s by USN/Motorola

- **One of the first fuzes to utilize a microprocessor**

Over 800,000 FMU-139A/B fuzes produced through 1995 by Motorola

USN developed FMU-139B/B in 2000 and upgraded its inventory:

- **Improved IM: Replaced CH-6 Booster with PBXN-7**
- **Improved ESD Protection: Added Transient Voltage Suppression**

ATK acquired Motorola fuzing design and production assets in 1998

FMU-139: Supporting Freedom for More Than 20 Years!

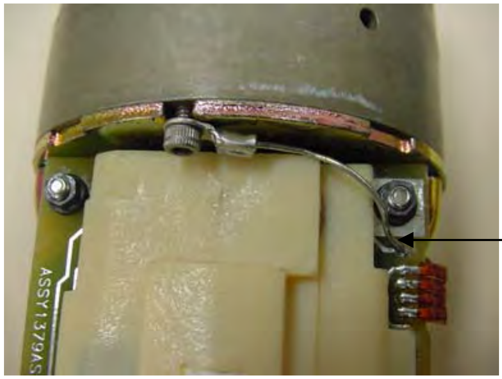
ATK FMU-139B/B History

An international market for FMU-139 existed but:

- **FMU-139A/B no longer producible - component obsolescence**
- **USN issued an FMU-139B/B performance specification**

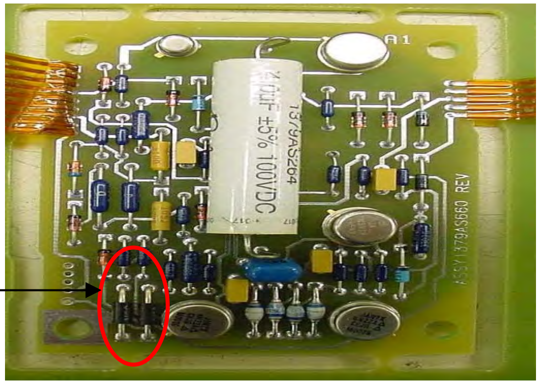
ATK Approach - retain proven design but address obsolescence:

- **Replaced COP4 microprocessor with COP8; rewrote software**
- **Replaced timing crystal, firing circuit thyristors, encapsulant**
- **Also incorporated USN FMU-139B/B IM and ESD improvements**



USN FMU-139B/B

ATK B/B incorporated Transient Voltage Suppression (TVS) components into main circuit board



ATK FMU-139B/B

Distribution Statement A approved for public release; distribution is unlimited.

ATK FMU-139B/B History (cont'd)

ATK

An advanced weapon and space systems company

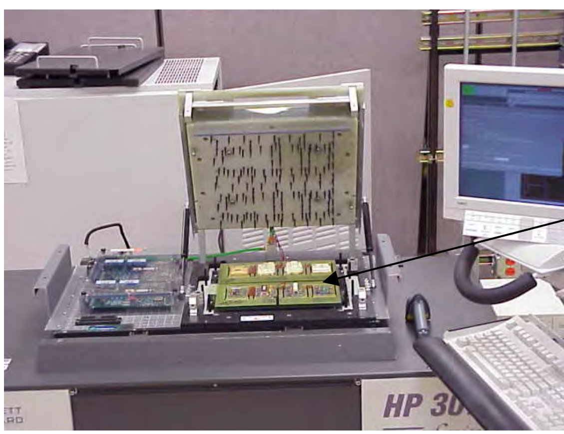
Navy design oversight and approval was required to assure safety, reliability, and interoperability:

- **Utilized a Commercial Services Agreement (CSA) with USN**
- **Design certification and safety approvals granted 2001 & 2002**

Passed software FQT and First Article Testing in 2001

Over 9,000 fuzes were delivered to several allied nations 2002 – 2004

USN oversight continued during international production via CSA



HP3070
CCA Tester

Performance assured by electronic testing at both board level and fuze level

EDT 4
Fuze Tester

Distribution Statement A approved for public release; distribution is unlimited.

FMU-139C/B Requirements

An advanced weapon and space systems company

New mission scenarios required longer time of operation in pulsed power (Navy FFCS) mode:

- **Increased mission life from 1 to 4 minutes**
- **Increased inrush current from 80 to 135 mA**

Improved safety required resolution of two legacy concerns:

- **Ensure microprocessor reset at power-up to preclude early enable (firing of piston actuator)**
- **Prevent out-of-sequence firing of Bellows Motor (at or before PA fire)**

FMU-139C/B Design Approach

An advanced weapon and space systems company

Continued spiral improvement to the proven FMU-139 family

Hardware Highlights:

- **Increase energy storage capacitance by 125%**
- **Use precision reference diodes (stabistors) for superior control**
- **Re-layout Printed Wiring Board**
- **Revise Gag Flex to short Bellows until cut by Gag Rod at enable**
- **Minimize changes – 7 new parts, 6 deletes, 16 value changes = 29 total**

Software Highlights:

- **Improve energy management**
- **Split initial firing capacitor charge into 2 phases**
- **Reduce firing capacitor refresh rate**

Risk Mitigation Highlights:

- **Perform Design Verification Testing (DVT) early**
- **Perform 20-unit Confidence Build after CDR**

FMU-139C/B Results

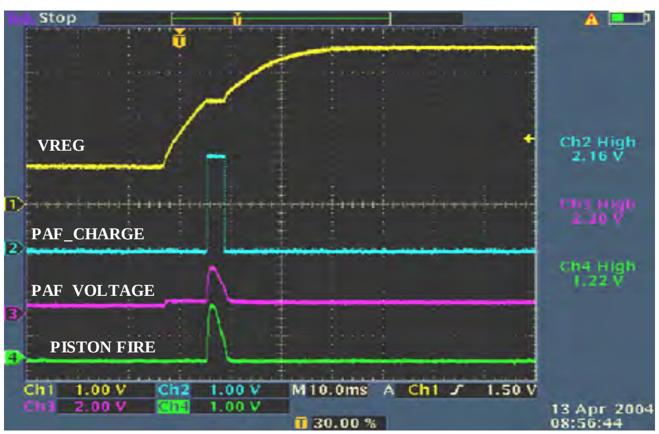
An advanced weapon and space systems company

Lifetime Requirement Met with Robust Margin!

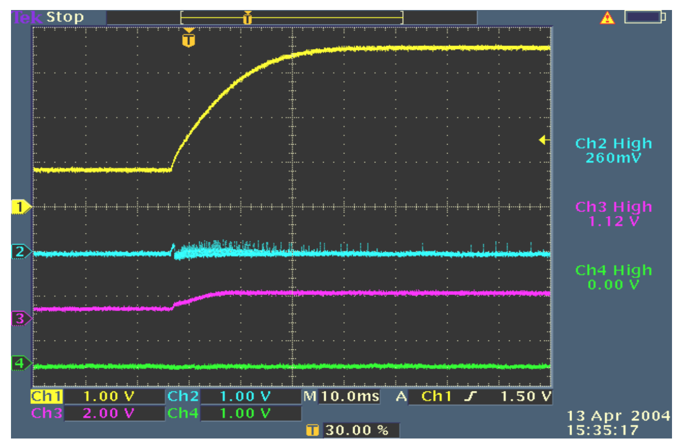
- Requirement = 240 sec, minimum
- Demonstrated = 330 sec (ambient), 300 sec (cold), 290 sec (hot)
- Max current draw of 135 mA met = 128 mA max observed

Safety Improved!

- Revised Gag Flex shorts Bellows until enable completed
- Reset Circuit improved to prevent early PA fire at power-up



Before – Note Enable at Power Up



After Reset Circuit Improvements

FMU-139C/B Status

Build of First Article fuzes has been completed

First Article Testing currently in progress and will complete in June

- **FAT must demonstrate 95% reliability at 90% confidence**

Required safety presentations have been made to the Navy Technical Review Panels – Fuze Initiation (FISTRP) and System Software (SSSTRP)

Initial Production delivery planned for September

FMU-139C/B Wrapup

- ✓ **Proven, legacy design fully understood**
- ✓ **New customer requirements fully understood**
- ✓ **Changes kept to a minimum**
- ✓ **Extensive testing performed**

RESULT: FMU-139C/B is on track!

The FMU-139 Fuze will continue to support freedom for years to come…..

ANY QUESTIONS??

<u>Contact Information</u>:

Dave Liberatore

ATK Tactical Systems

(304)726-7587

dave.liberatore@atk.com

THANK YOU!

Performance Testing of Lead-Free Stab Detonators

05/11/2006
NDIA Fuze Conference

Author: Neha Mehta
RDECOM
Chemical Engineer

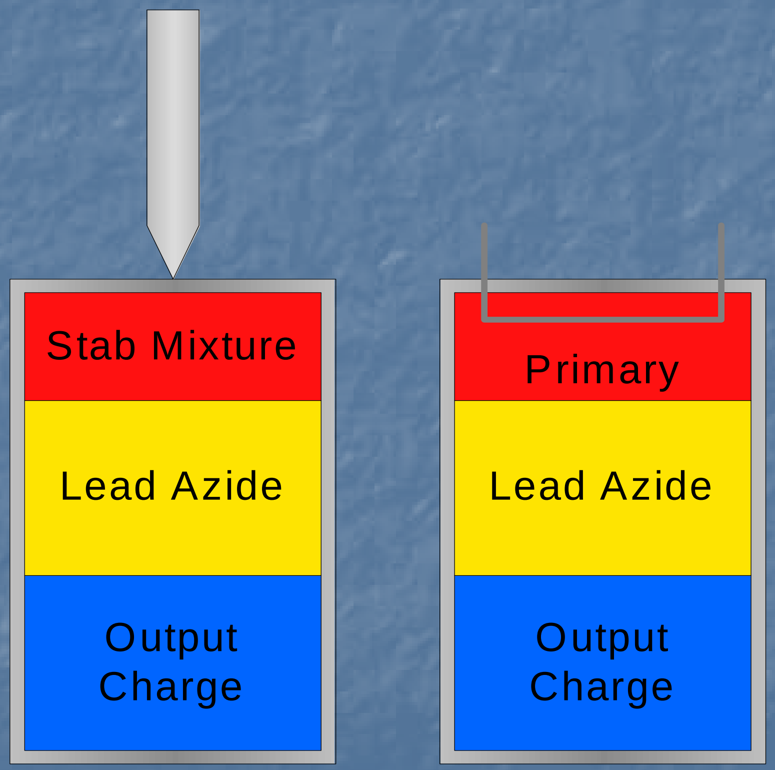
Co-Authors:
Gartung Cheng - RDECOM
Emily Cordaro – RDECOM
Neelam Naik - RDECOM
Bobby Lateer - RDECOM
Carl Hu – RDECOM
Daniel Stec – SAIC
Kathy Yang - SAIC

Outline

- Introduction
- Objective
- Initiating Charge Replacements
- Transfer Charge Replacements
- New Detonator Design
- Benefits
- Test Results and Comparison
- Questions

Introduction

- Current issues with primary explosives in detonators:
  - No US Lead Azide production
  - Environmentally hazardous
- Initiated a program to develop a lead-free stab detonator



Program Objectives

- Replace NOL-130 (initiating charge) and Lead Azide (transfer charge) with green materials.

Initiating Charge Replacements

- Replacing the initiating charge will eliminate some of the lead
  - Must initiate with same stimulus
  - Must be powerful enough to cause transfer charge to detonate
- Lead-free stab mixture
  - Based on NOL-130
  - Lead-based components replaced

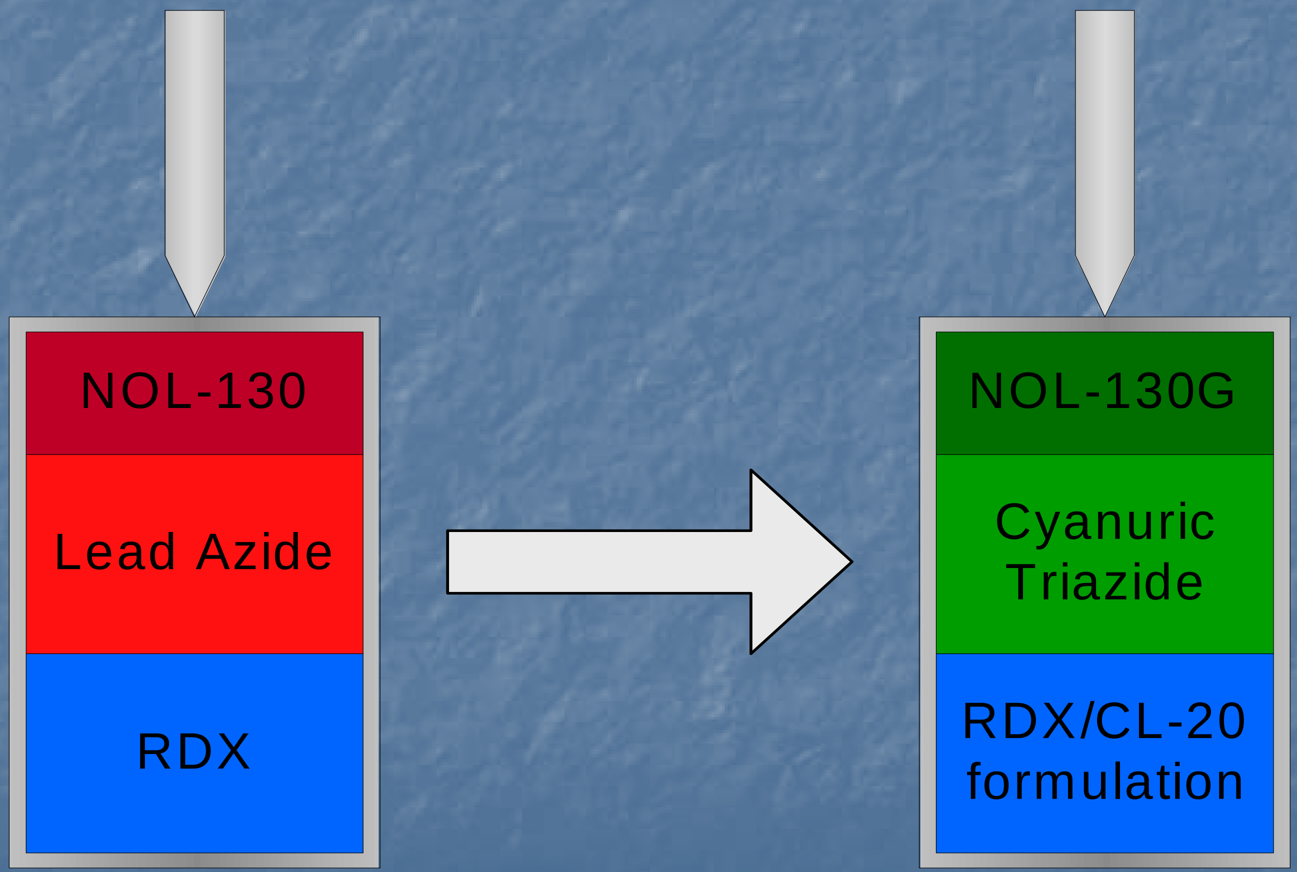
Initiator Mix Composition

NOL-130	NOL-130G
Lead Azide	Cyanuric Triazide
Lead Styphnate	
Tetracene	Tetracene
Barium Nitrate	Barium Nitrate
Antimony Trisulfide	Antimony Trisulfide

Transfer Charge Replacements

- Replacing the transfer charge will eliminate rest of the lead
  - Must be sensitive enough for detonation transfer
  - Must be powerful enough to cause high order reaction of output charge
- Cyanuric Triazide

Lead-Free Stab Detonator



Benefits

- Lead-Free Material
- Give US manufacturing capability
- Eliminates single point failure source in fuze/detonator supply chain
- Utilizes present technology for preparation and production
- Simple production process, with low waste, non-toxic

Sensitivity Tests

- Ball Drop Impact
  - LA: 7-11”
  - NOL-130: 14”
- Electrostatic
  - LA: No Go at 0.0012J

    GO at 0.0016J

- Ball Drop Impact
  - Cyanuric Triazide: 10”
  - NOL-130G : 9-14”
- Electrostatic
  - Cyanuric Triazide (as formed):

    No Go at 0.031 J (0/20)
  - Recrystallized Cyanuric Triazide:

    No Go at 0.0012 J (0/20)

Sensitivity Tests

- Small Bam Friction
  - LA: No Go at 10-20g
    GO at 30g

- Small Bam Friction
  - Cyanuric Triazide (as formed):
    No Go at 10g (0/10)
    Go at 20g
  - Recrystallized Cyanuric Triazide:
    Go at the minimum load - 10g

Detonator Ball Drop Test Setup

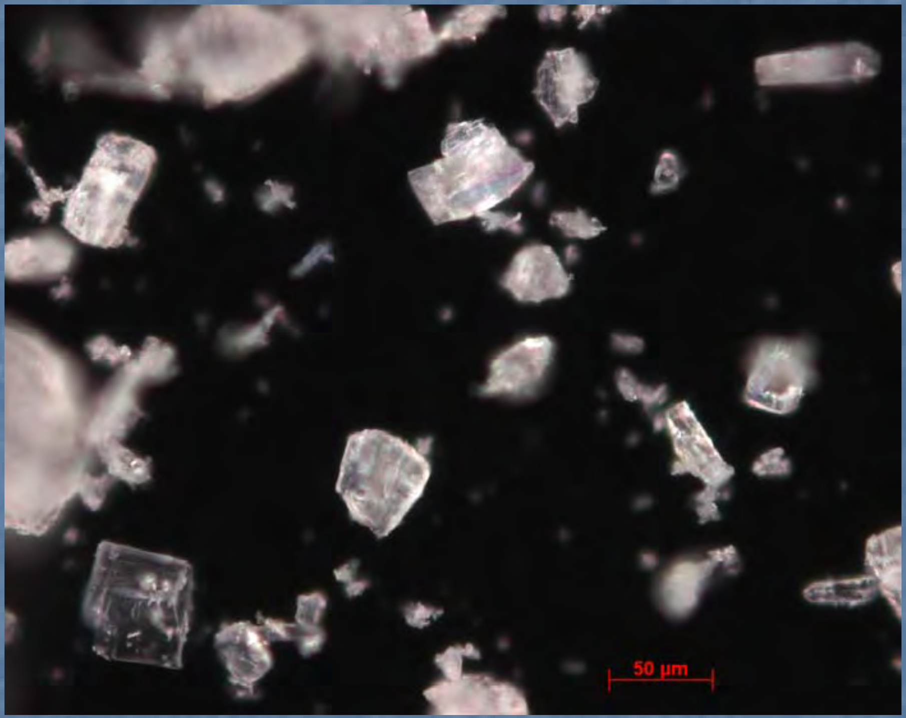
M55 Detonator Holder

M55 Detonator – Ball Drop Test

#	NOL-130 (mg)	NOL-130G (mg)	Lead Azide (mg)	Triazide (mg)	RDX (mg)	EDF (mg)	Comments
1	15			29			GO
2	15			37			GO
3	15			20	19		GO
4	15			20		19	GO
5		15	51		12		GO
6		15		20	17		GO
7		15		20		17	GO

Witness Plates

Microscopy



As Formed

Recrystallized

Conclusions

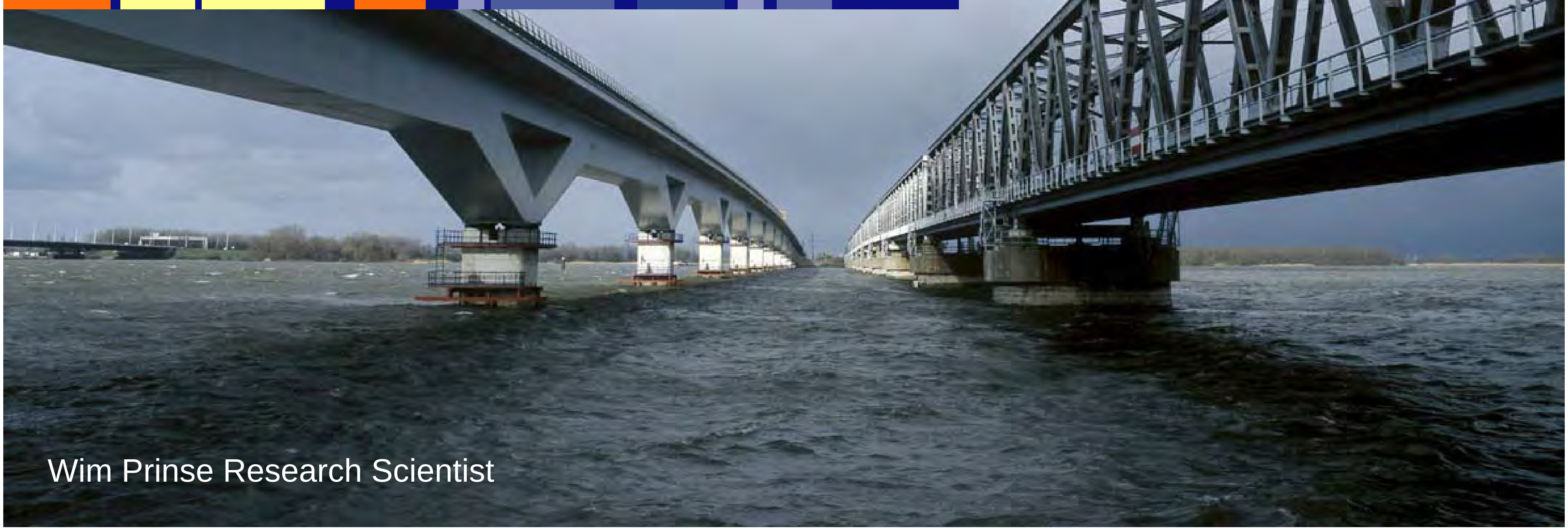
- Developed new stab composition, NOL-130G.
- Replaced Lead Azide with Triazide.
- Investigated the replacement of the output charge with a CL-20 formulation.
- Approved to file a Patent for NOL-130G and Lead-Free Stab Detonator.

Future Work

- Optimize particle size of cyanuric triazide.
- Optimize loading of the transfer and output charges.
- Qualify Cyanuric Triazide and NOL-130G.

Research on EFI's in relation to Insensitive Munitions

TNO | Knowledge for business



Wim Prinse Research Scientist

Contents

- TNO Organisation
- Exploding Foil Initiator Research
- Research on Explosives
- Conclusion

TNO has organised its business in five core areas

TNO Quality of Life

TNO Defence, Security and Safety

TNO Science and Industry

TNO Environment and Geosciences

TNO Information and Communication Technology

TNO Defence, Security and Safety focuses on:

- **Defence**
  - Military operations
  - Military equipment
  - Command and operational decision making
  - Threat and protection
  - Education and training
- **Security and Safety**
  - Combating crime, calamities and terrorism
- **Aerospace**
  - Improving safety
- **Maritime**
  - Shipbuilding

Organisation TNO Defence, Security and Safety

Managing Director Core Area

- Director of Marketing and Sales
  - Manager of Marketing and Sales
- Director of Knowledge
  - Manager of Knowledge
- Director of Operations
  - Manager of Operations

Business Unit 1 Observation Systems

Business Unit 2 Systems and Support for Decisions and Operations

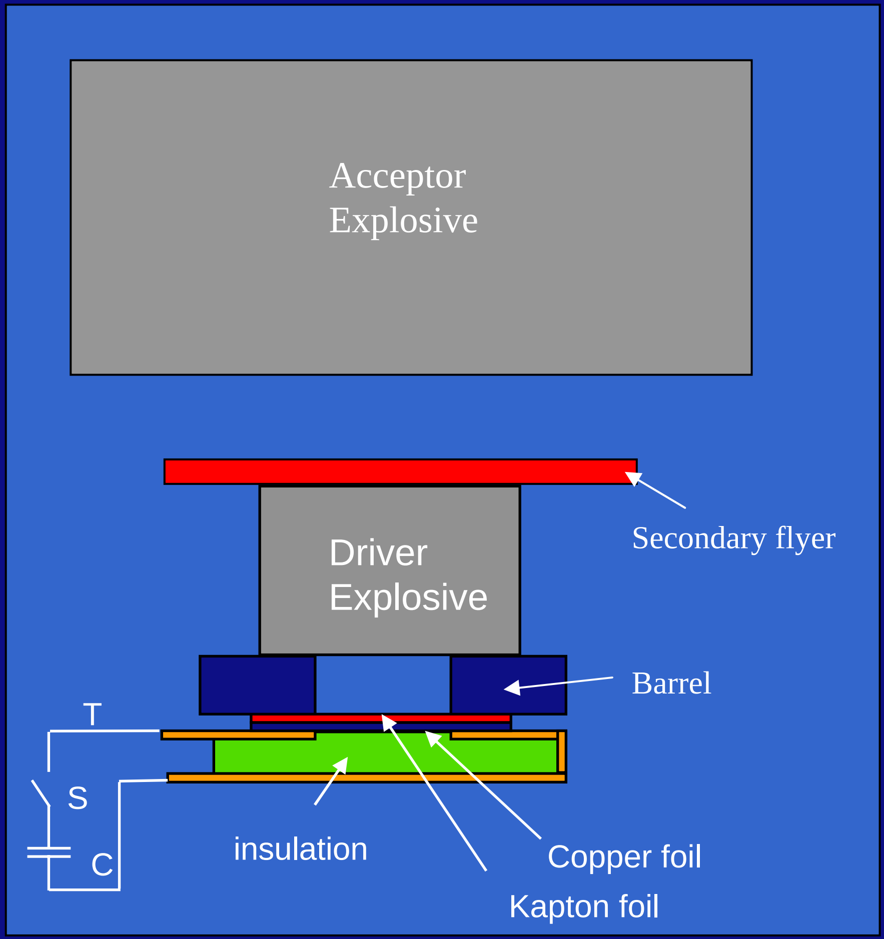
Business Unit 3 Protection, Munitions and Weapons

Business Unit 4 Biological and Chemical Protection

Business Unit 5 Human Factors

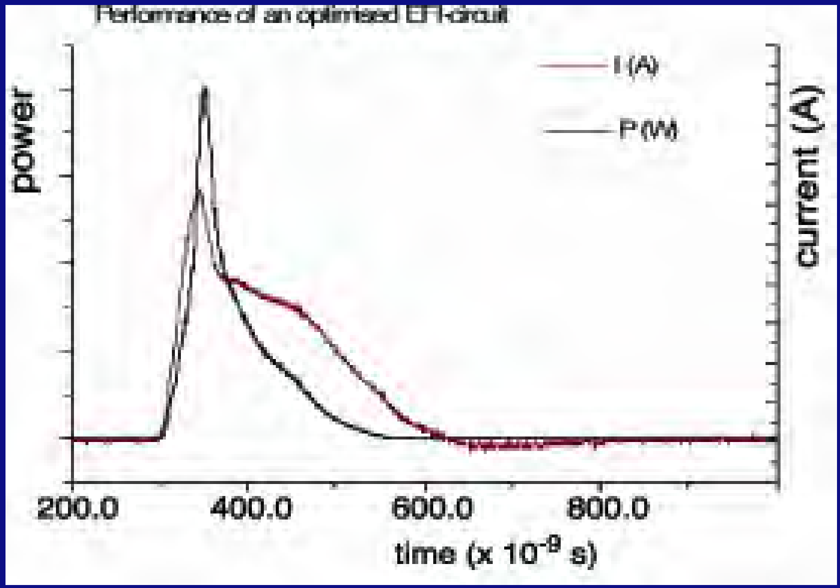
Exploding Foil Initiator Research

- Electrical circuit
- Exploding foil
- Velocity of the flyer
- Driver Explosive
- Secondary flyer
- Acceptor explosive



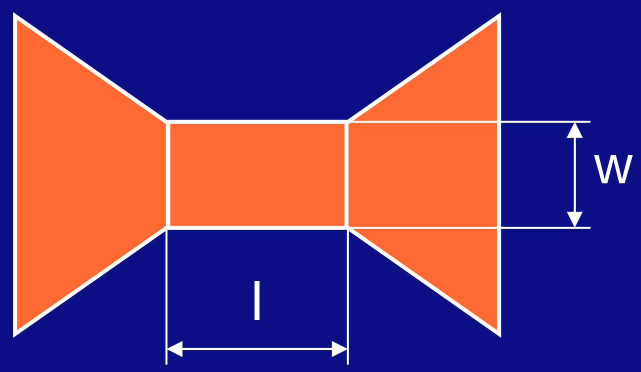
Electrical circuit

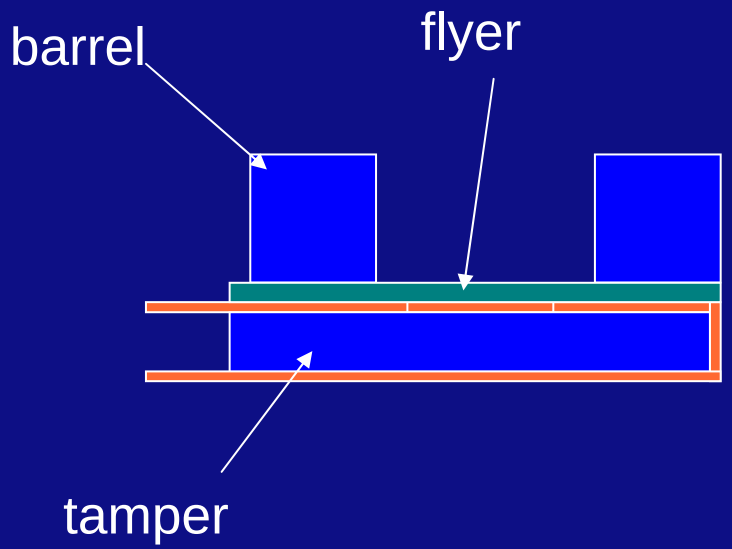
- Optimisation of the circuit
  -low loss capacitor,
  -switch,
  -transmission line
- Development of measuring techniques
- 90% efficiency of energy deposited in the exploding foil (50 % other circuits)



Exploding foil

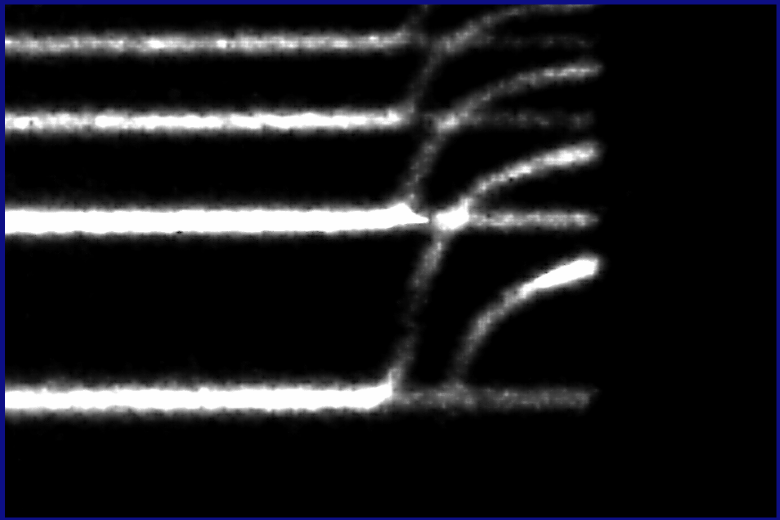
- Dimension of the foil (length, width, thickness, material)
- Shockwave impedance of the tamper
- Thickness and material of the flyer
- Length and width of the barrel

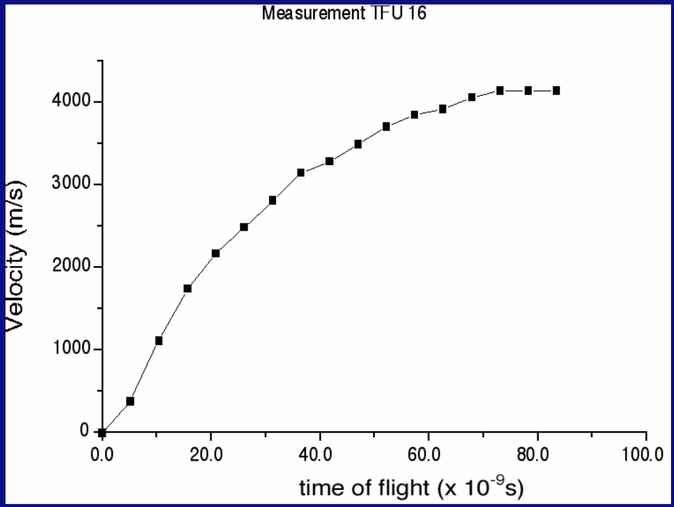




Flyer velocity measurement by F-P Interferometer

- Acceleration of the flyer influenced by:
  -thickness and material
  -exploding foil dimensions and material
  -shockwave impedance of the tamper
- Integrity of the flyer during acceleration
  -Determination of optimum barrel length



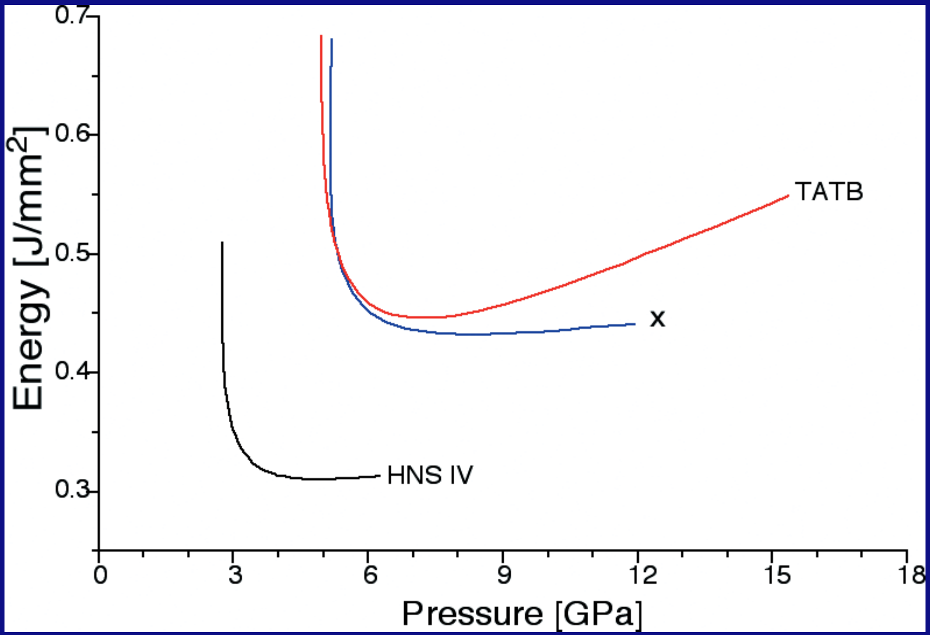


Research on Explosives I

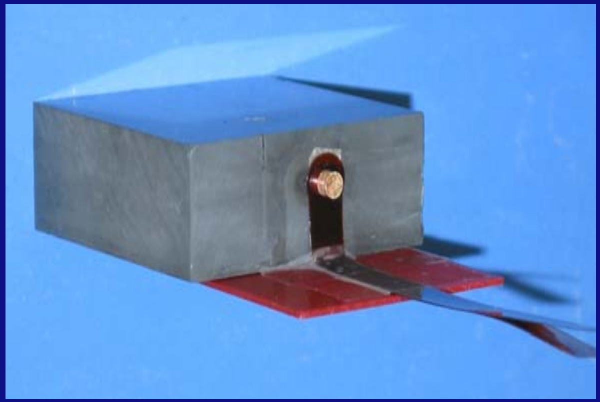
- Recrystallisation of HNS II to HNS IV
- The crystals are more uniform (smaller distribution)
- The length to width to thickness is 10:3:2
  a further increase in specific surface area is possible

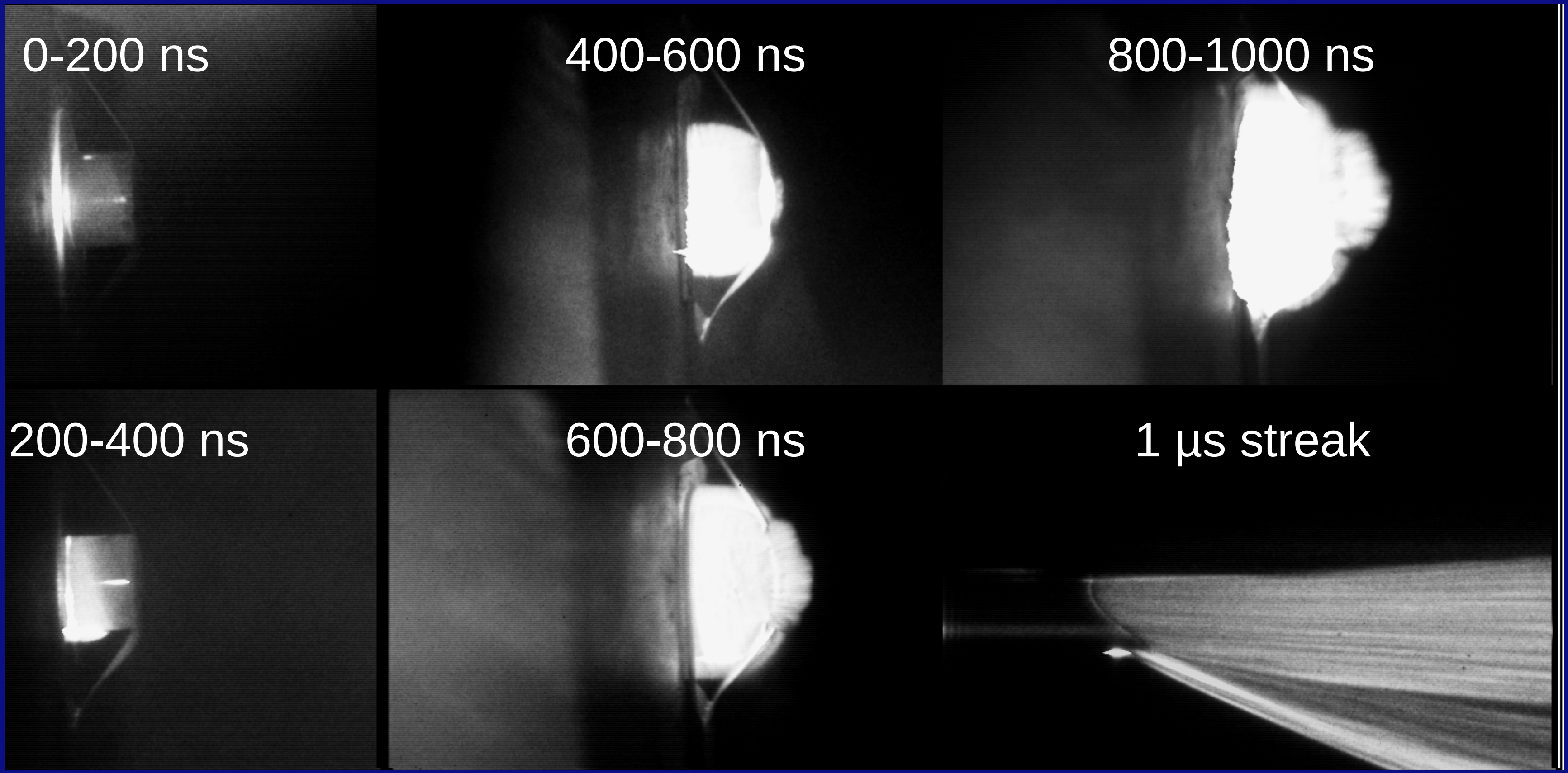
Initiation behaviour of different explosives

- Different types of explosives
  - HNS IV several brands
  - TATB several grades
  - New explosives
- Initiation energy depends on flyer thickness and velocity



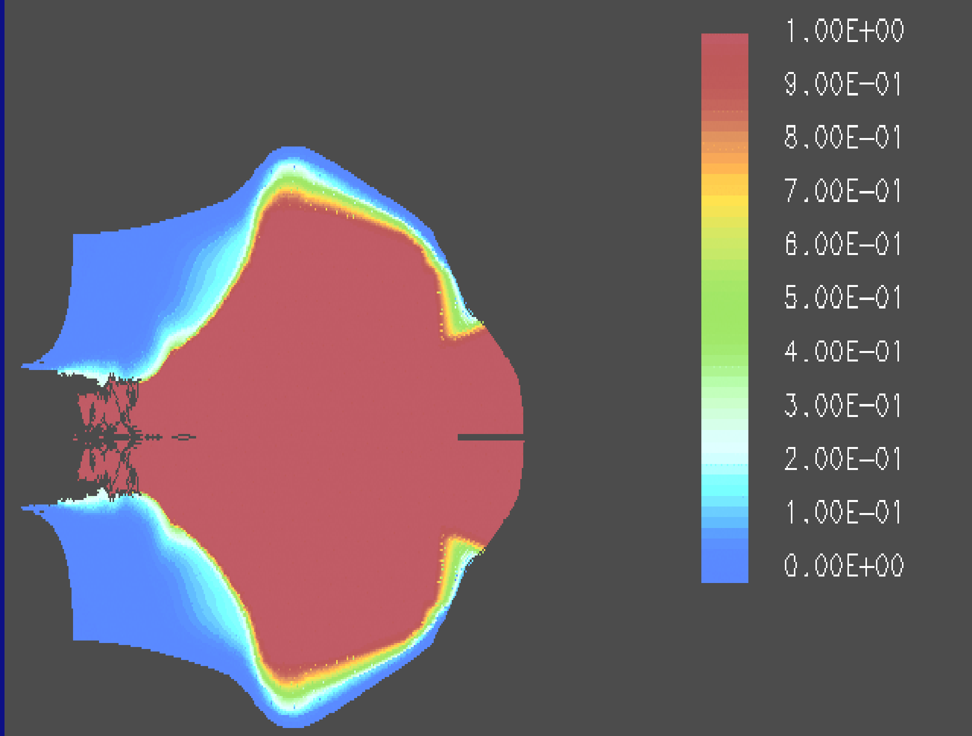
Initiation of HNS IV pellet





Numerical simulations of flyer impact

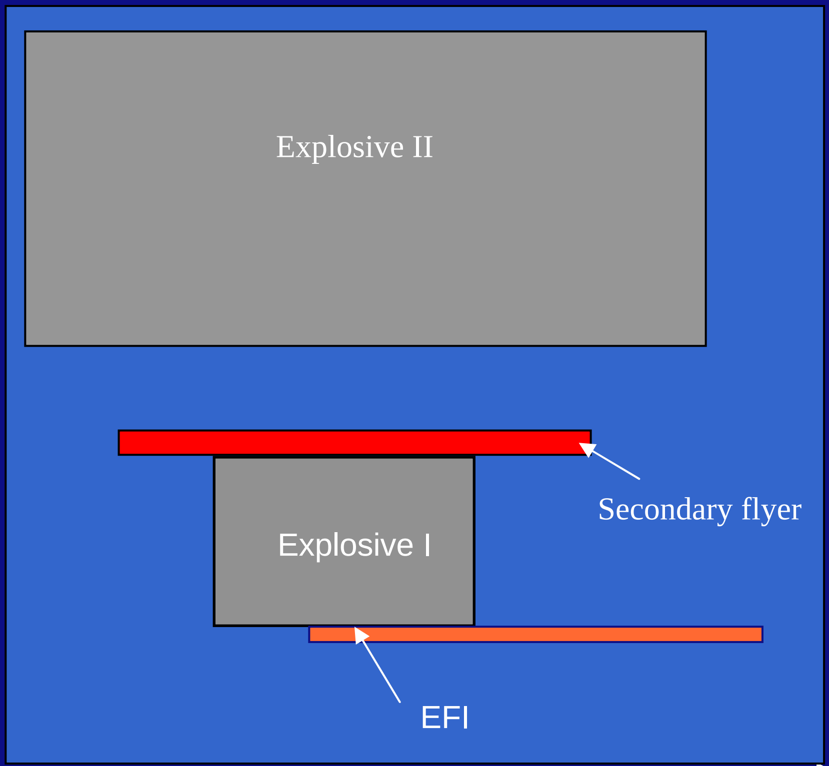
- Lee-Tarver model modified with visco-plastic pore collapse model
- Qualitatively the simulations can explain the experiments



Reacted fraction of HNS IV after initiation by 5.4 mm/µs flyer

Secondary flyer impact

- Driver explosive (HNS IV, TATB, RDX ……..)
- Confinement of the explosive
- Secondary flyer material:
  - spall strength (attenuator)
  - shockwave impedance
  - size and thickness
- Initiation distance of acceptor explosive

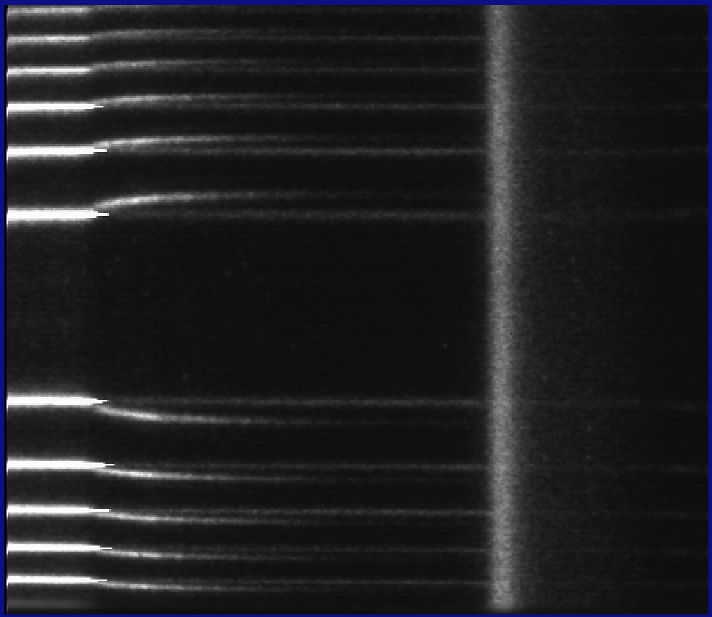


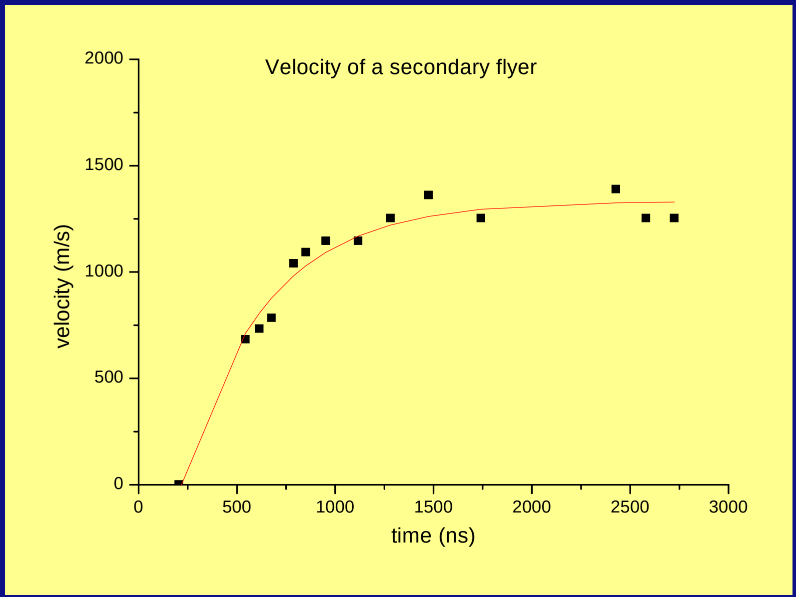
Secondary flyer impact

Acelleration of a 0.25 mm stainless steel flyer by HNS IV

Successful initiation of TATB by

- 0.15 mm SS steel flyer
- 0.35 mm mylar flyer
- 0.3 - 0.5 mm Al flyer





Conclusions

- A very efficient electrical circuit is developed (η = 90%)
- With “of the shelf components” small IM compliant EFI-detonators can be build (8 cm^3 including HV-supply)
- Combining the EFI with the electronic safety and arming unit with MEMS-technology can make a small and cost effective unit
- The use of secondary flyers makes the detonation train more reliable

Pieter van ‘t Hof
Pieter.vantHof@tno.nl

Wim Prinse
Wim.Prinse@tno.nl

NDIA
NATIONAL DEFENSE INDUSTRIAL ASSOCIATION

50th Annual Fuze Conference
Norfolk, VA May 09 – 11, 2006

JUNGHANS
Feinwerktechnik

Introduction of the Multi Option Fuze Artillery (MOFA) DM84 on 120mm Rifled Mortar

JUNGHANS Feinwerktechnik GmbH & Co. KG
Jochen Wagner

DIEHL
VA Systeme

Artillery Howitzer PZH 2000

JUNGHANS Feinwerktechnik

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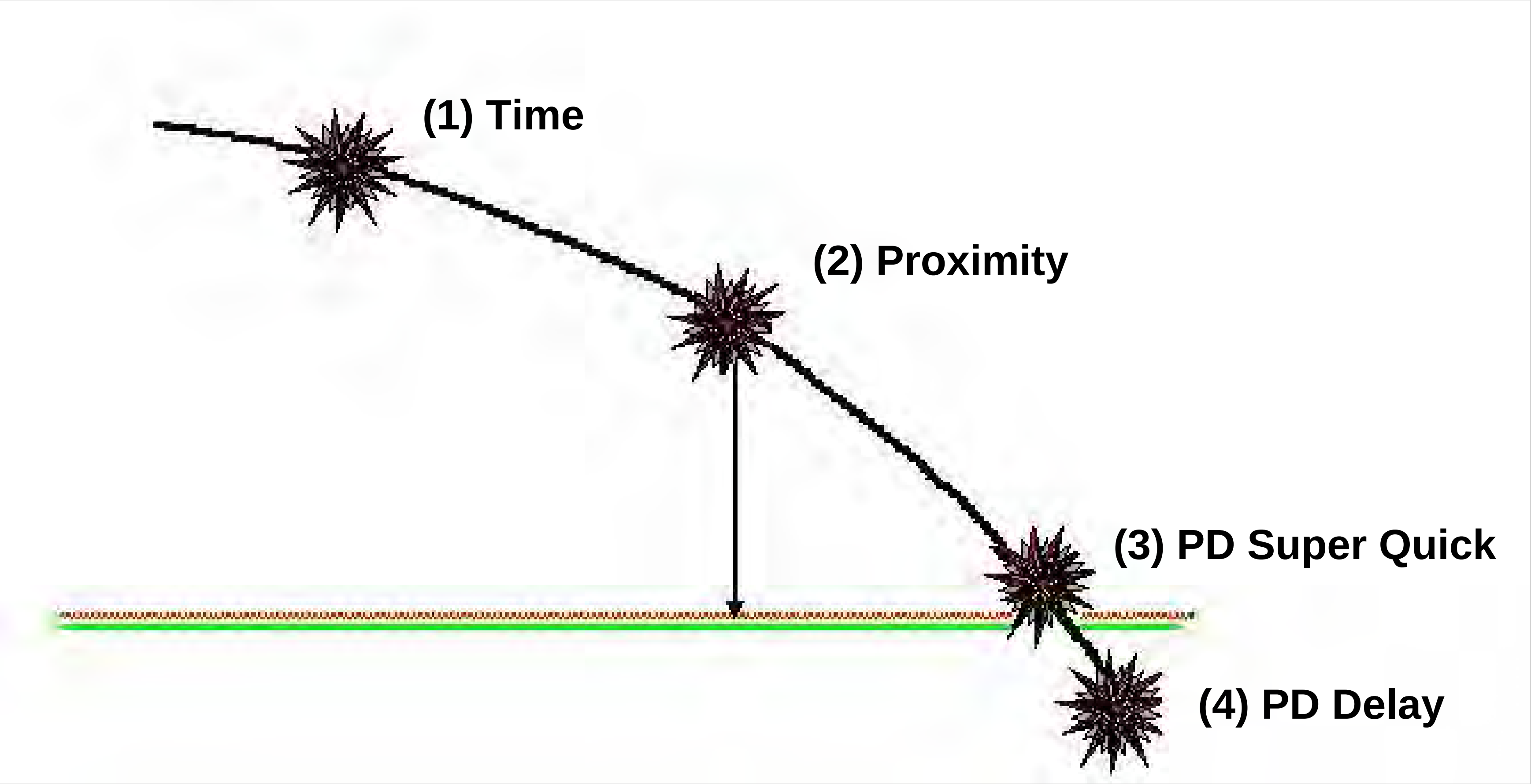
Fuze types mortar / artillery – functioning



DM34, DM34A1 Proximity Fuze

JUNGHANS Feinwerktechnik

- Function: Proximity,
  Point Detonating SQ or Delay
- Manually Settable
- Not Jamable
- Produced for
  German Armed Forces
  (DM34 in service since 1988,
  DM34A1 in service since 1994)
  Swedish Armed Forces
  (DM34A1-S as ÖFZONAR94 MK in service since 1996)
  Norwegian Armed Forces
  (DM34A1 as BRANRØR PPD MN187 in service since 1997)
- More than 250.000 ea. fielded

DM74 Multi Option Fuze

JUNGHANS Feinwerktechnik

- Function: Proximity, Time, Point Detonating SQ or Delay
- Inductively Settable
- Overflight Safety T-4
- Not Jamable
- Produced for
  German Armed Forces
  (in service since 1997)
  Canadian Armed Forces
  (as C32 in service since 1998)
  Danish Armed Forces
  (in service since 2000)
- More than 270.000 ea. fielded

DM84 Multi Option Fuze

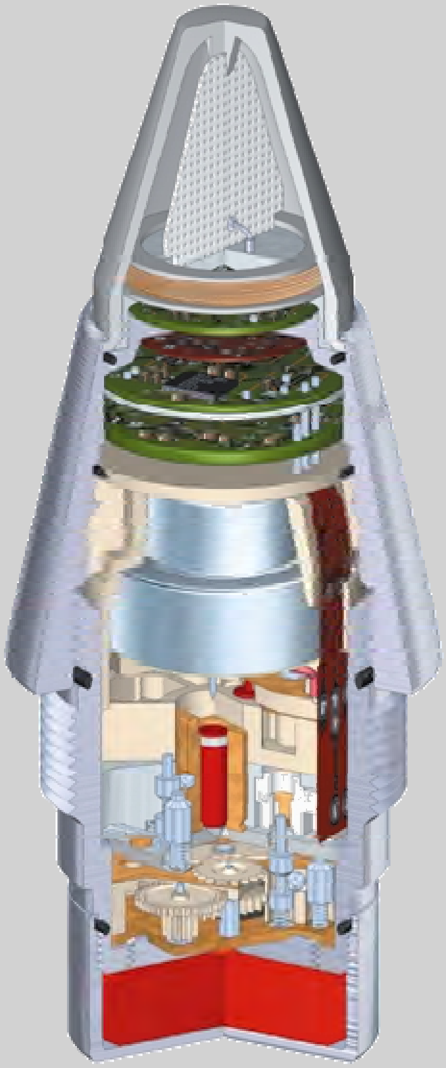
JUNGHANS Feinwerktechnik

<u>Usage</u>

- on 105 mm / 155 mm high explosive artillery shells
- Field Howitzer 105mm
- Field Howitzer 155mm, 39cal. Barrel
- Self Propelled Howitzer 155mm, 39cal. Barrel
- Self Propelled Howitzer 155mm, 52cal. Barrel
- 120mm Rifled Mortar

DM84 Multi Option Fuze

JUNGHANS Feinwerktechnik



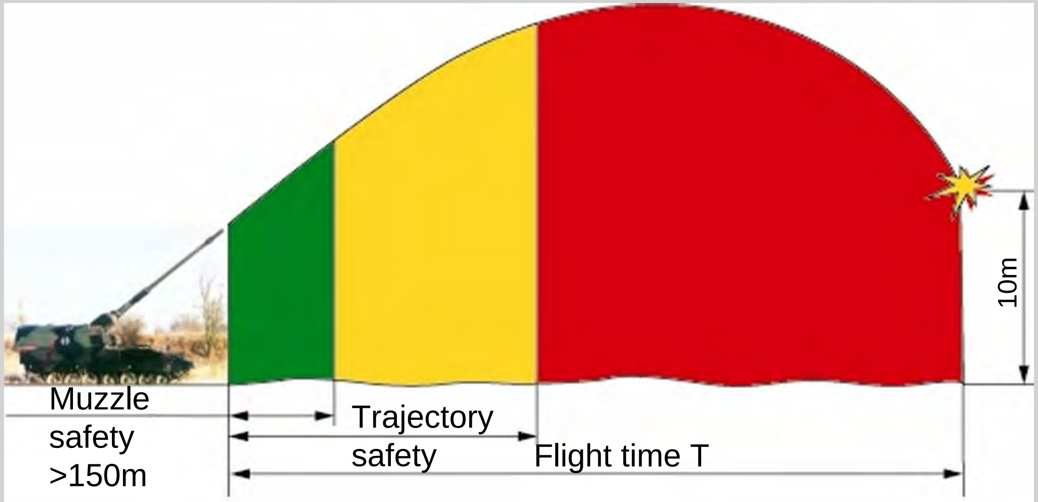
Further information

- derived from the DM74
- Proximity, Time, PD with and without delay
- two heights of burst (10m / 4m) in PROX mode
- inductive settable (acc. to STANAG)

- reserve Battery with S&A Mechanism
- flick-ramming safe
- delivered to the Dutch Armed Forces
- Adapted to be used on 120mm rifled mortars

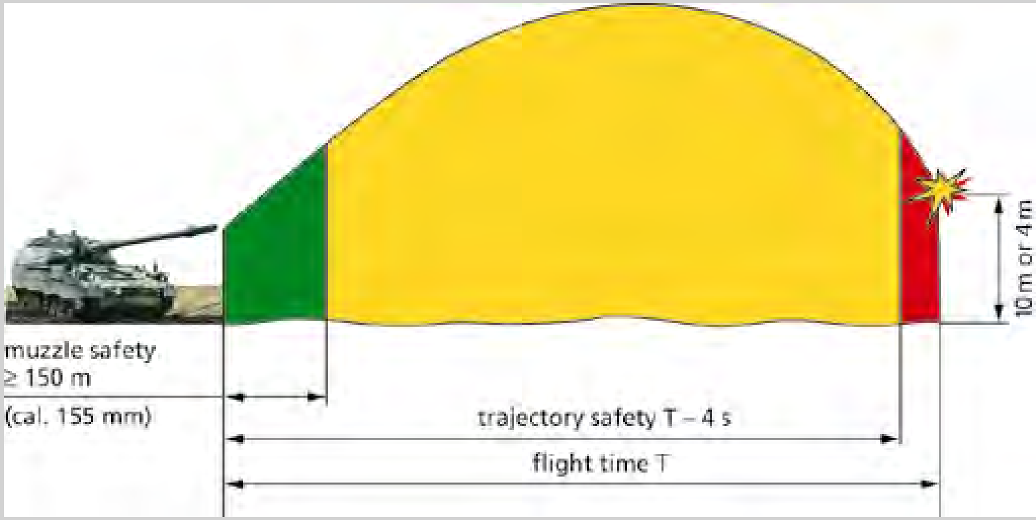
Trajectory Safety JUNGHANS MOFA DM74/DM84

JUNGHANS Feinwerktechnik



Factory (default) setting

- Muzzle Safety >150m (490ft)



Inductive programmed

- Muzzle Safety >150m (490ft)
- Trajectory safety T-4s

120mm Rifled Mortar

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DM84 Multi Option Fuze

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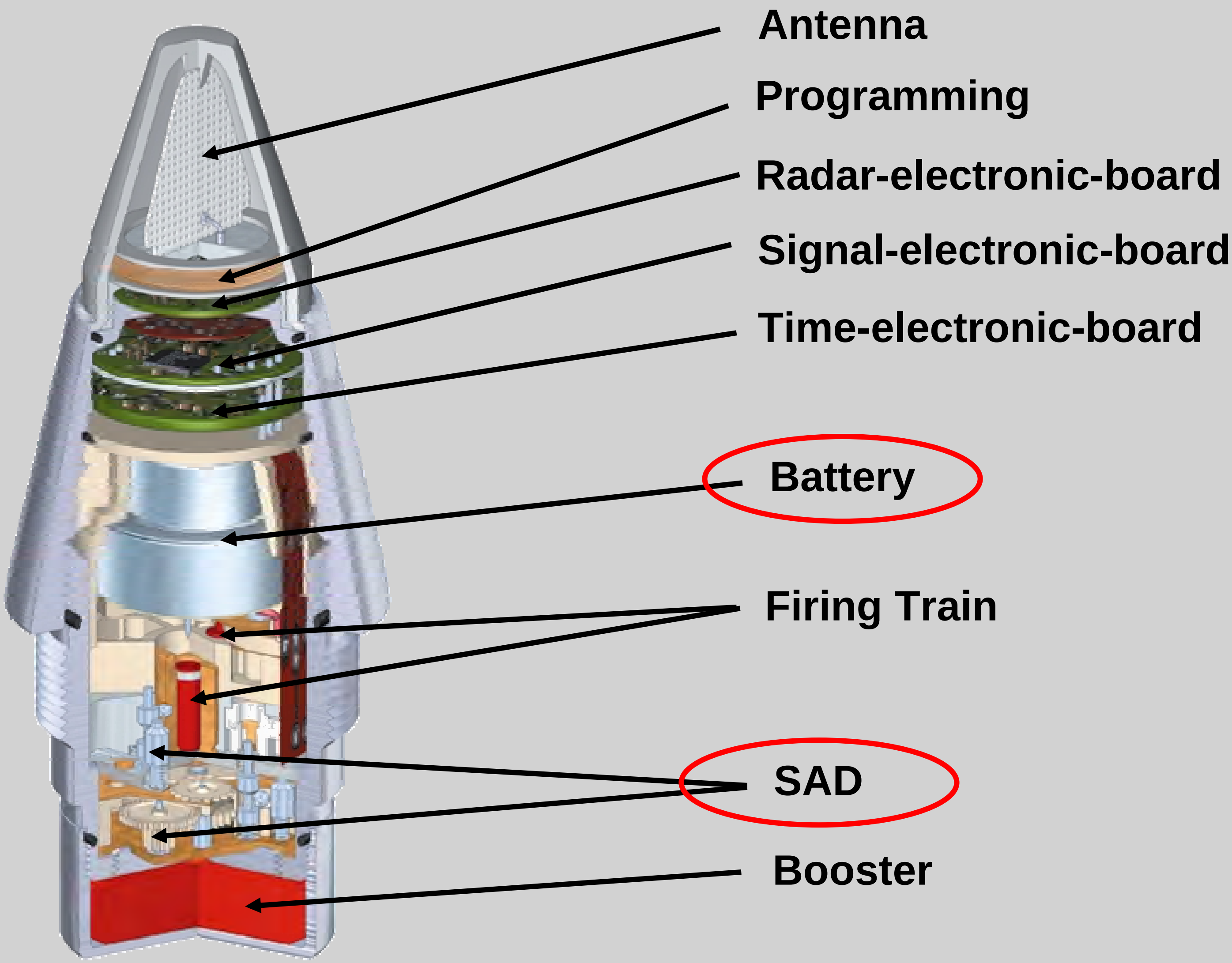

DM84 Multi Option Fuze adaptation

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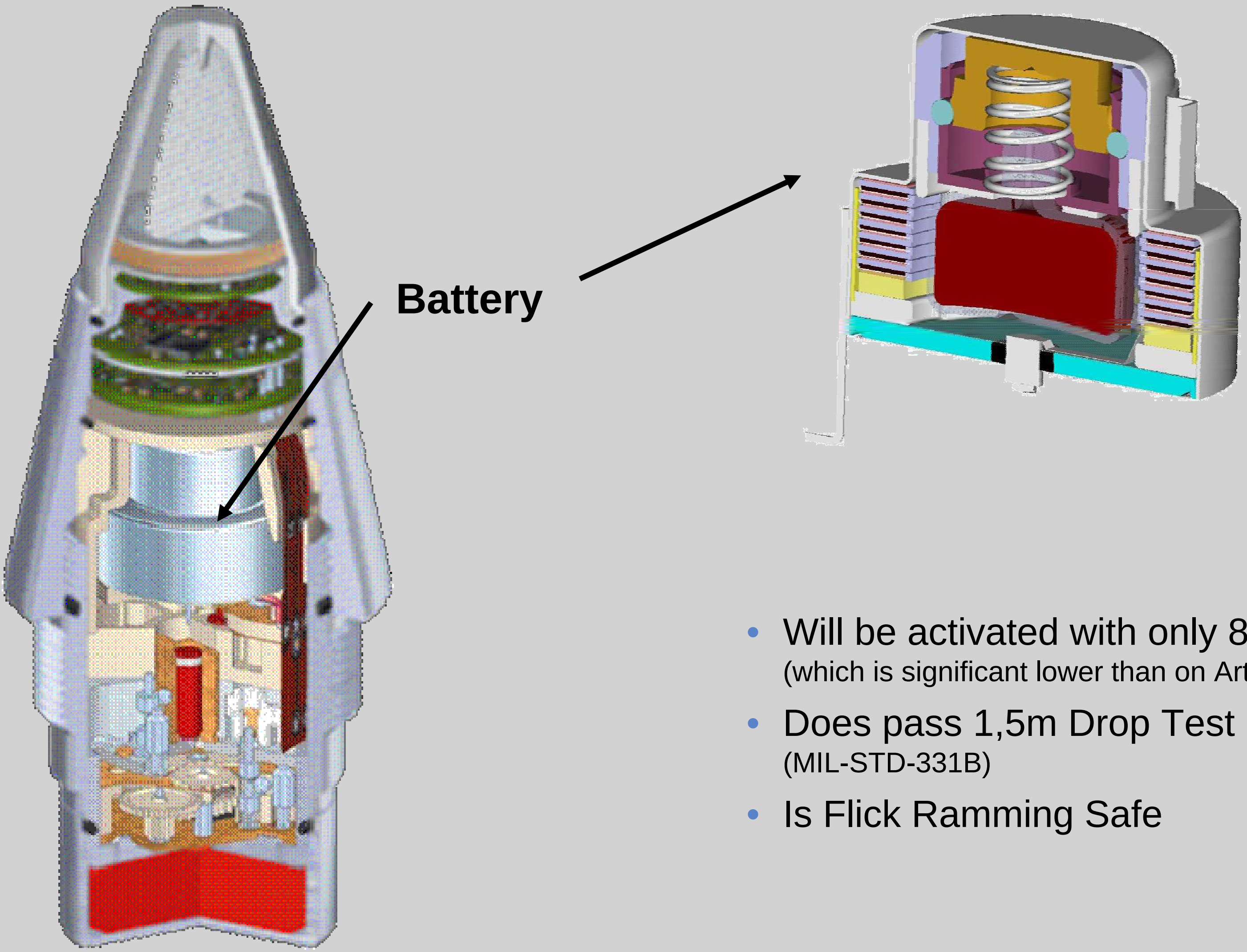
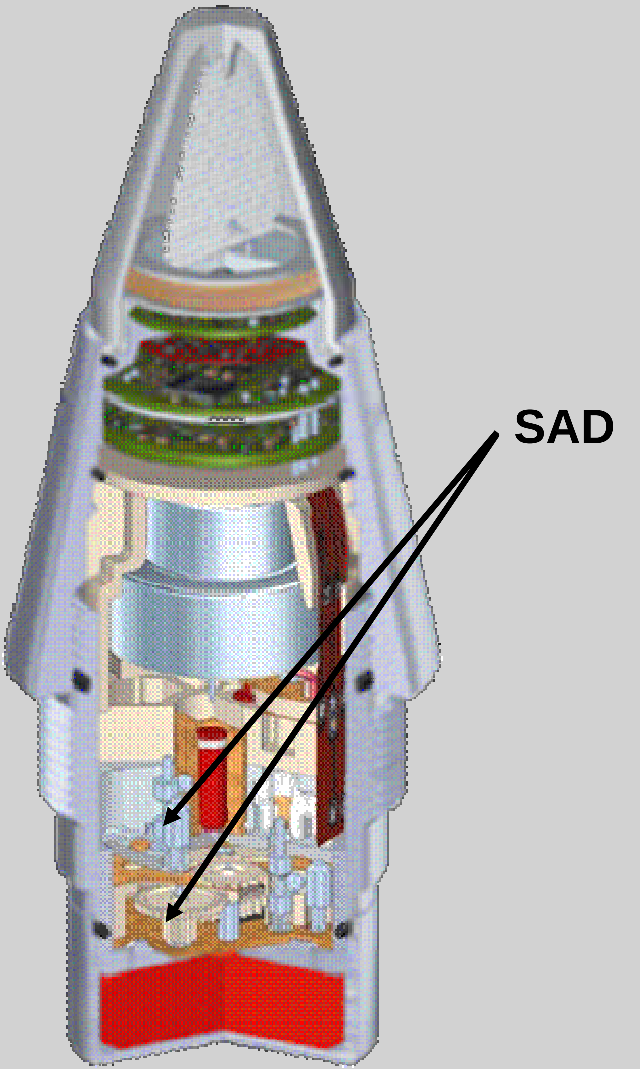
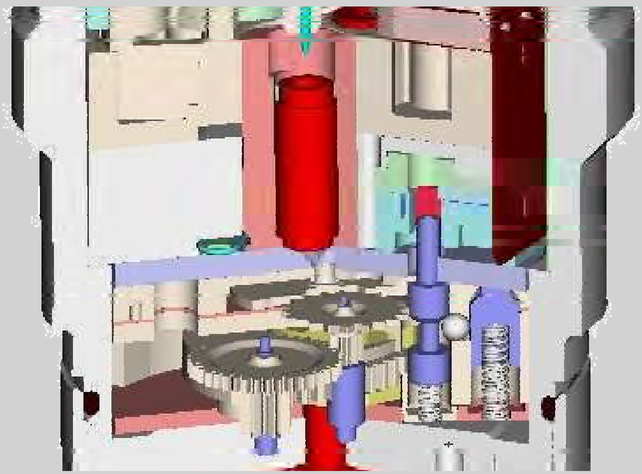


- Will be activated with only 850g
  (which is significant lower than on Artillery)
- Does pass 1,5m Drop Test
  (MIL-STD-331B)
- Is Flick Ramming Safe

DM84 Multi Option Fuze adaptation





- Will be activated with only 850g
  (which is significant lower than on Artillery)
- Does pass 1,5m Drop Test
  (MIL-STD-331B)
- Is Flick Ramming Safe

DM84 Multi Option Fuze for 120mm Rifled Mortar

JUNGHANS Feinwerktechnik

Summary

- DM84 offers a more sophisticated use of 120mm rifled mortars and improves the users options and system efficiency
- Using one fuze for artillery and mortar reduces logistics burden
- Training can be standardized
- DM84 is fielded in a NATO country

JUNGHANS Feinwerktechnik GmbH & Co. KG

Thank you for your kind attention !

Providing America Advanced Armaments for Peace and War

ARDEC

ENHANCED PORTABLE INDUCTIVE ARTILLERY FUZE SETTER (EPIAFS)

PRESENTED TO THE NDIA FUZE SYMPOSIUM

May 10, 2006

EXCALIBUR

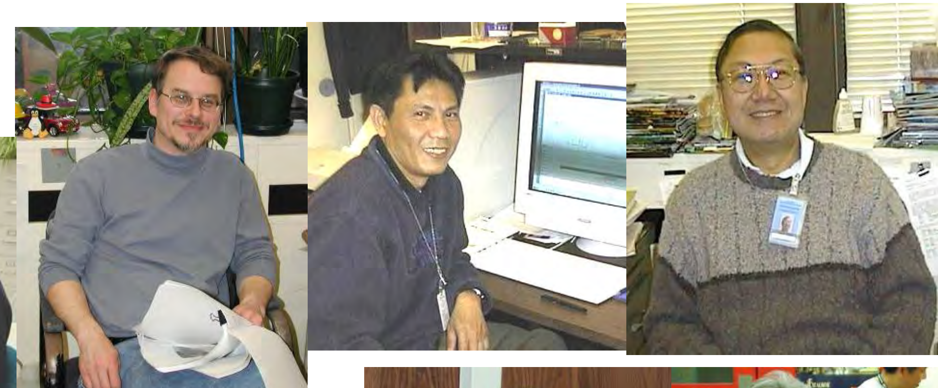
XM982

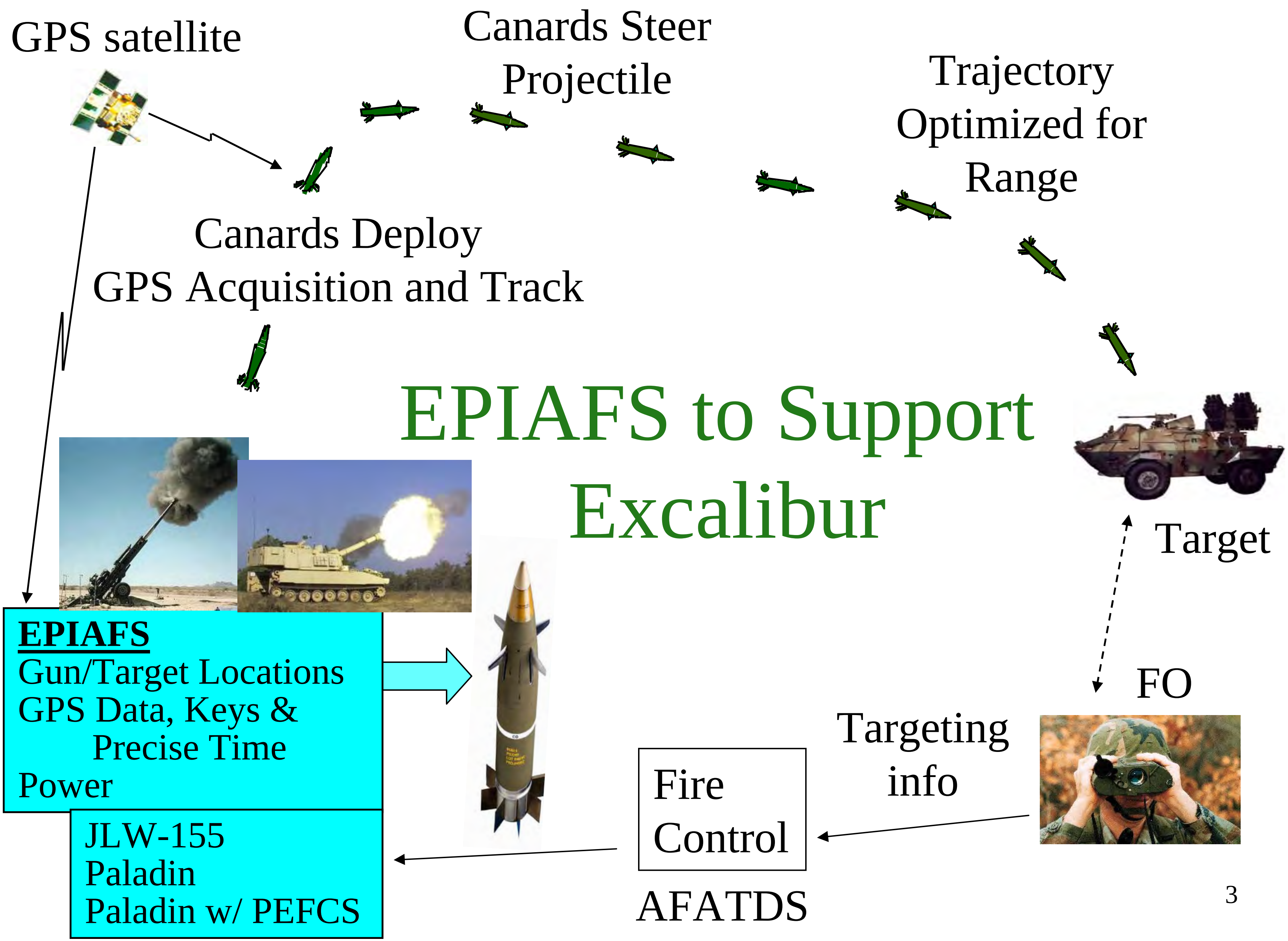
TOM WALKER

Committed To Excellence

EPIAFS TEAM

- Sponsor: PM-Excalibur LTC Cole
  - Chris Grassano
  - Mike Burke
  - MAJ Foster
- System: Ray Sicignano
  - Tom Coradeschi
- Platform Integration: Allison Marston
  - Fred Gloeckler
- User: Ft Sill
  - Steve Pearson
  - Bernie Garcia
- Software
  - Andy Leshchyshyn
  - Craig Freed
  - Paul Knors
- Mechanical
  - Jim Hartranft
  - Spencer Hum
  - Jr. Knisley
  - Rob Wood
- Electrical
  - Debbie Calomiris
  - Len Goodman
  - Hai Pham
  - Fred Oliver
  - Mary Labib
  - James Wiltz
  - Tom Walker
  - Jerry Frazier
  - Brent Beauseigneur


GPS satellite
Canards Steer
Projectile
Trajectory
Optimized for
Range
Canards Deploy
GPS Acquisition and Track
EPIAFS to Support
Excalibur
Target
EPIAFS
Gun/Target Locations
GPS Data, Keys &
Precise Time
Power
JLW-155
Paladin
Paladin w/ PEFCS
FO
Targeting
info
Fire
Control
AFATDS

EPIAFS SYSTEM

- PLATFORM INTEGRATION KIT (PIK)
  - Single board computer
  - Interface circuit
- SETTER and Cable

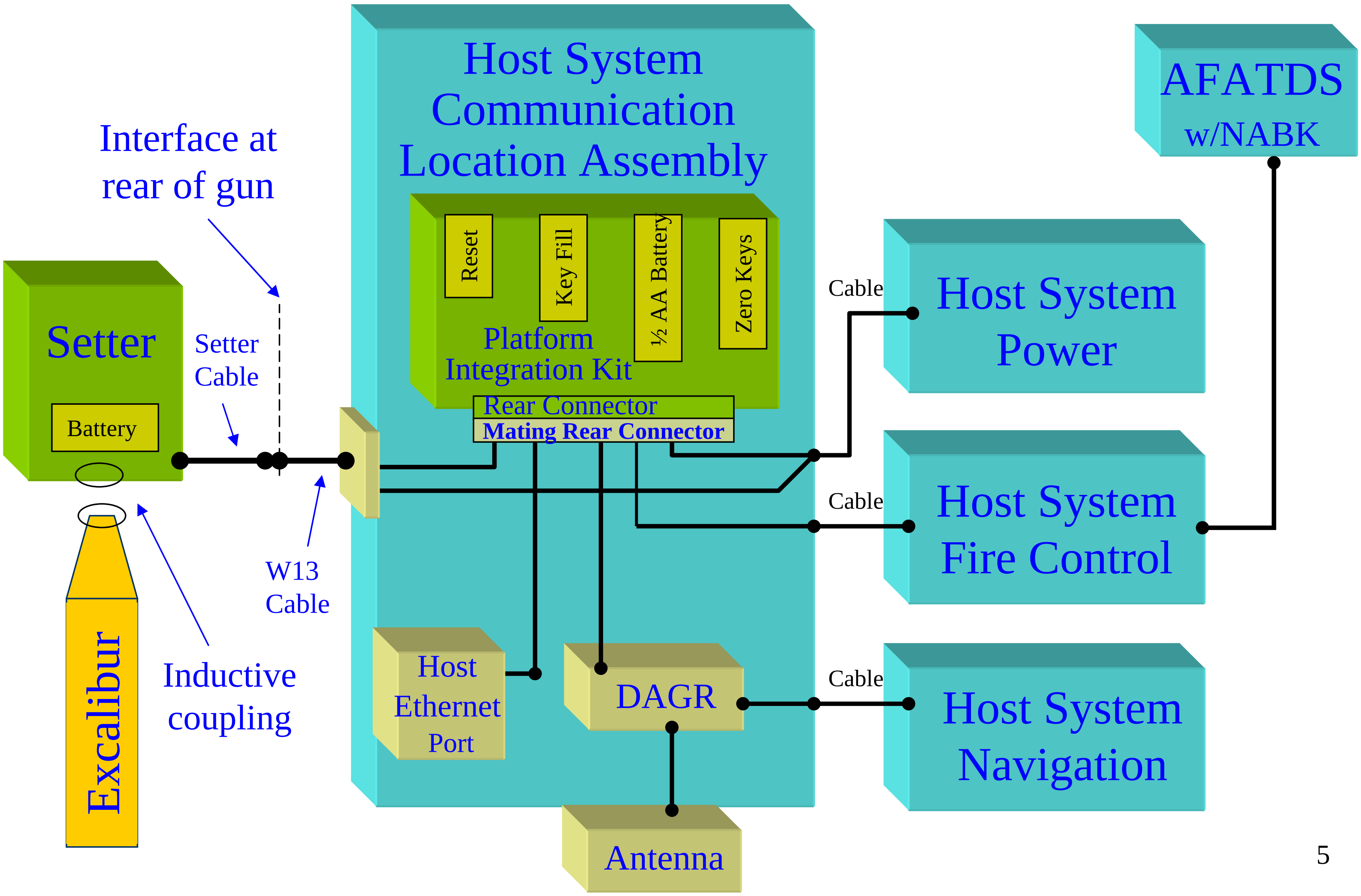
➢ EPIAFS utilizes DAGR

SETTER

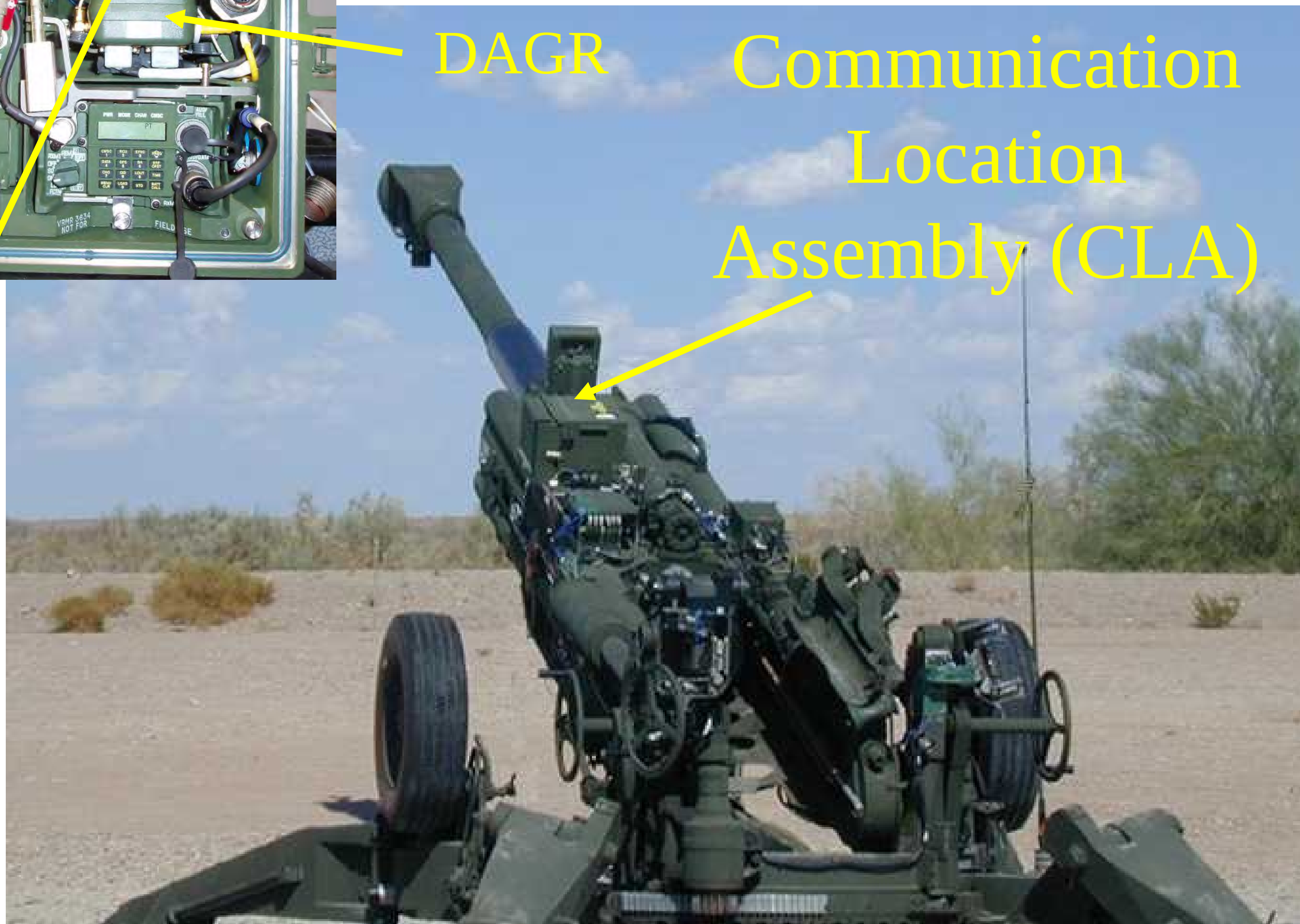
CABLE

PIK

EPIAFS System Integrated into JLW155



EPIAFS Host: M777E1

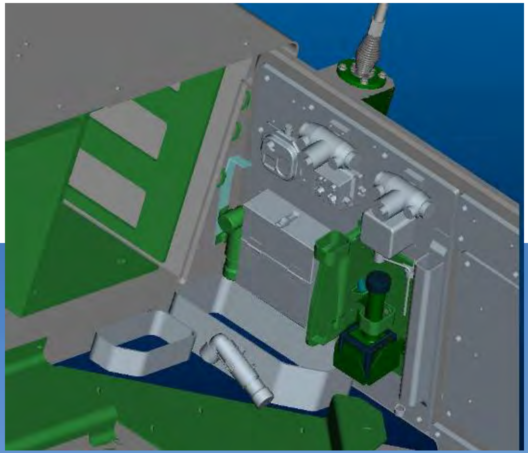


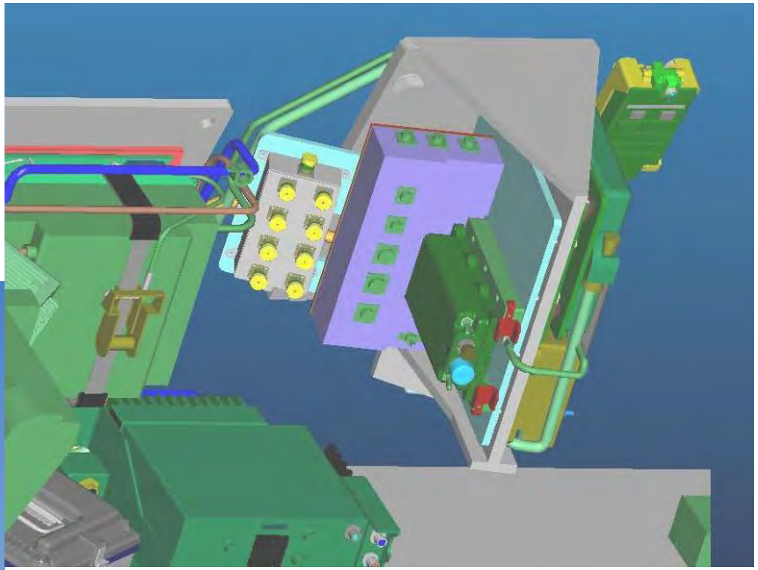
PIK mounts inside CLA

JLW Crew Setting Excalibur GNC

FQT Dry Run

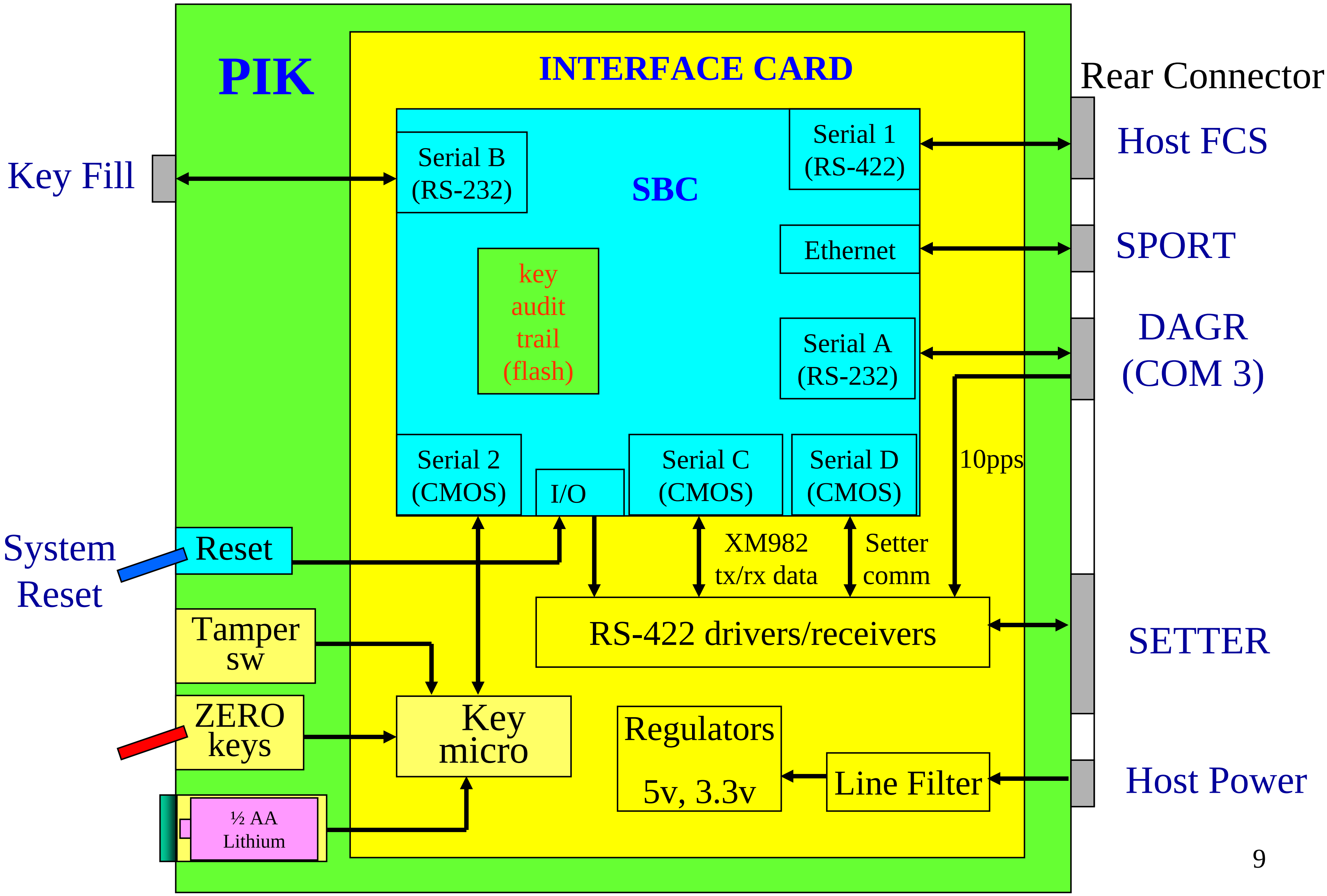
EPIAFS Host: Paladin





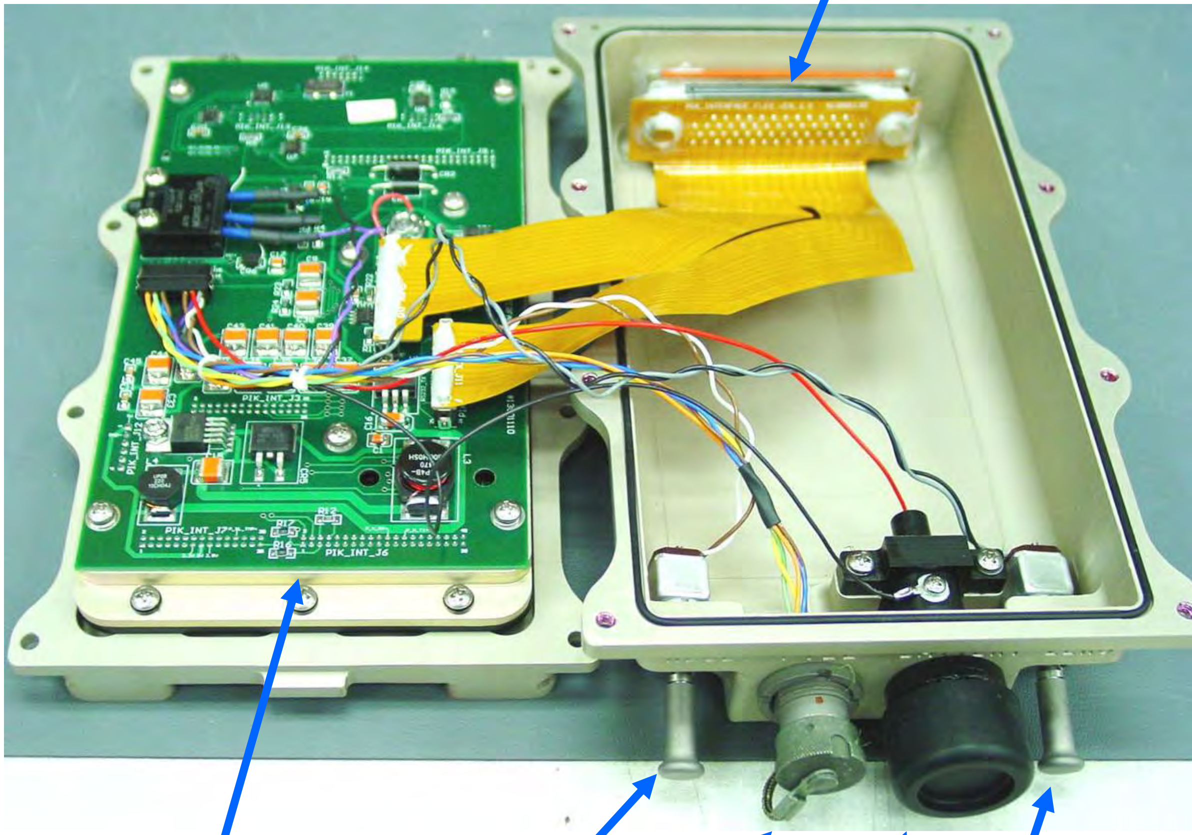
Paladin w/ PEFCS

PIK BLOCK DIAGRAM

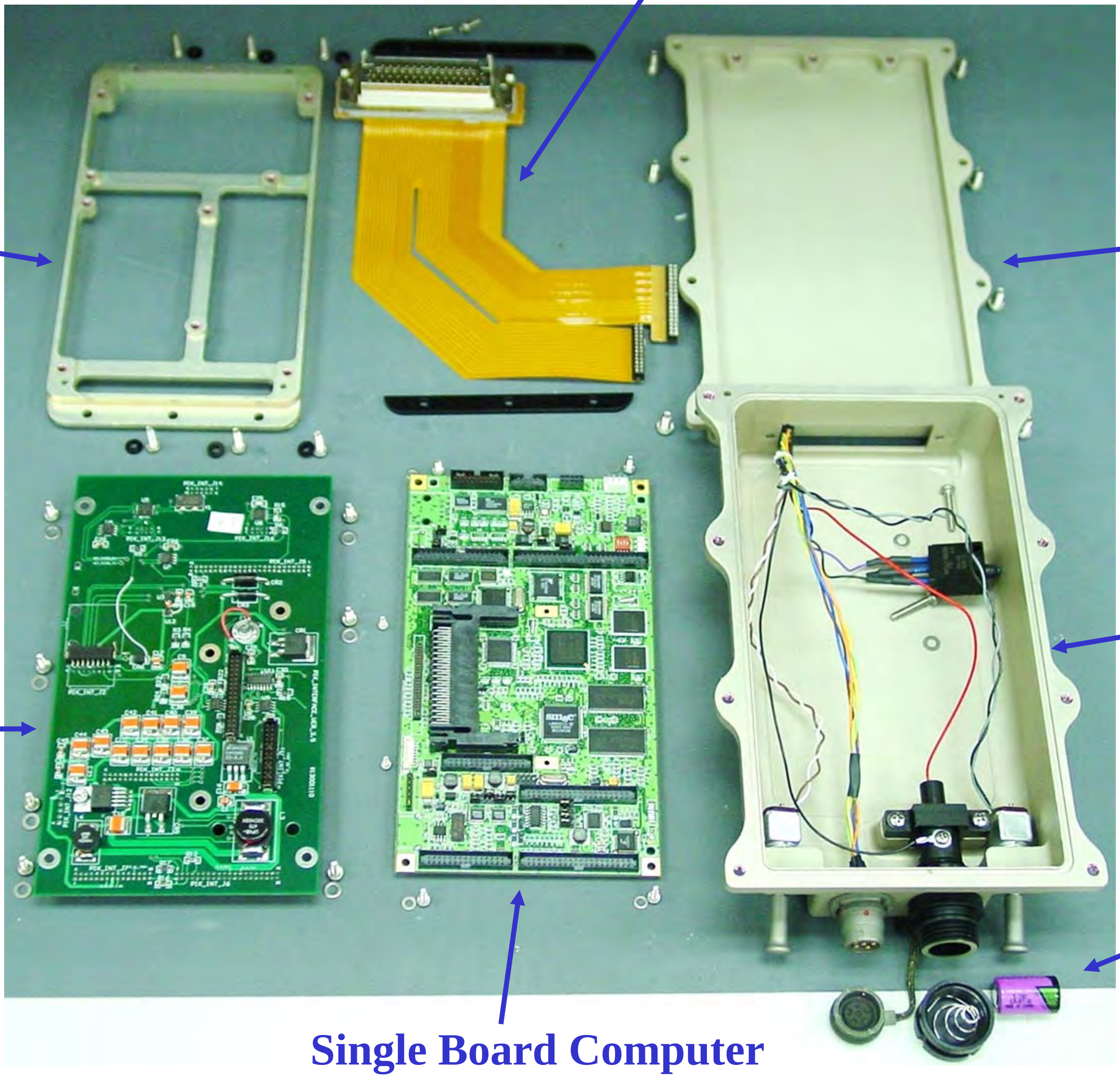


PIK FUNCTIONS

- Formats and sends all XM982 initialization data and TMP's through Setter
- Passes Standard Fuze Data to Setter
- Interfaces with Host system
- Interfaces with Key Loader
- Stores black GPS crypto keys and Audit Trail
- Interfaces with SPORT or MSD

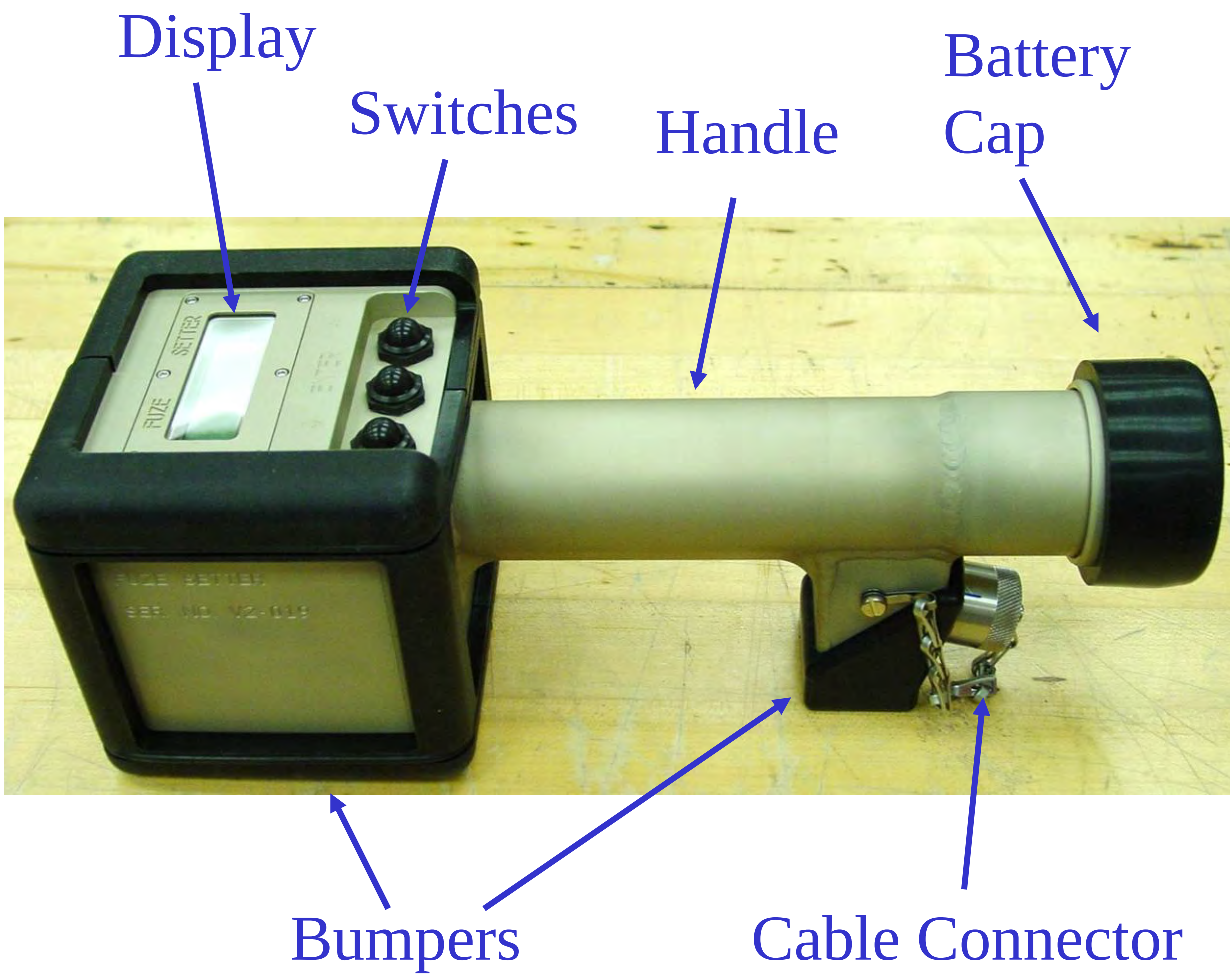


PIK Hardware

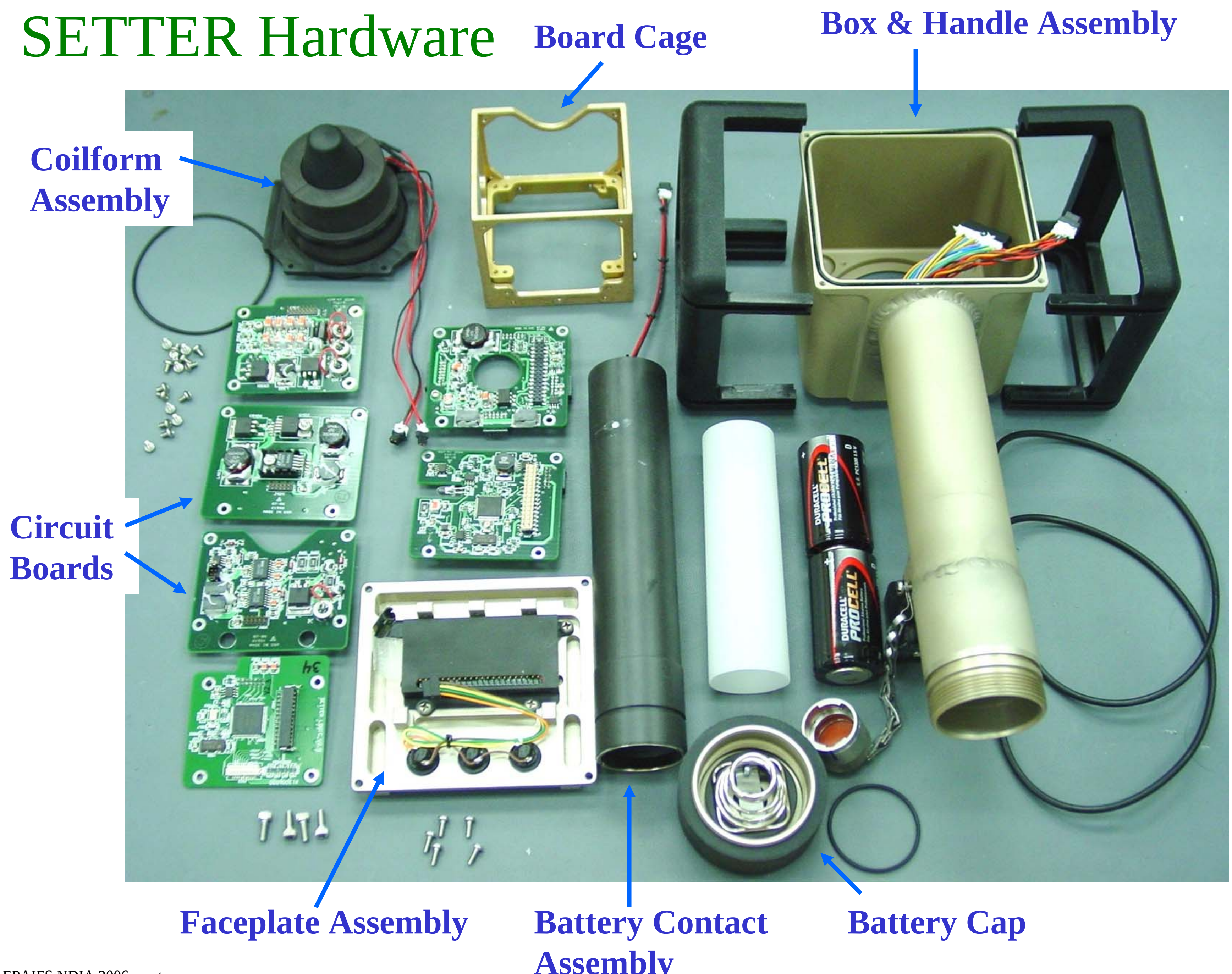


SETTER FUNCTIONS

- Interface with PIK
- Interface with standard fuzes and XM982
- Convert XM982 data stream to power/data format
- Interface with user via 3 switches and LCD
- Un-cabled setting for standard fuzes

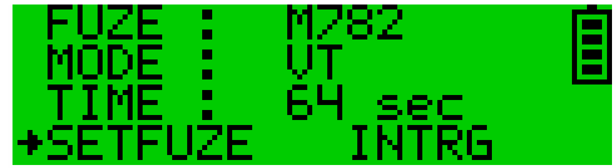


SETTER Hardware

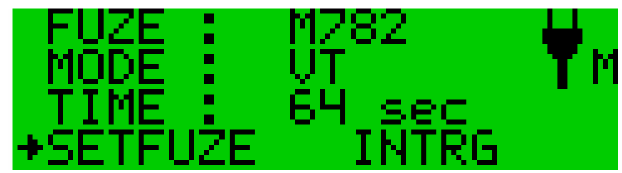


3 SETTER MODES

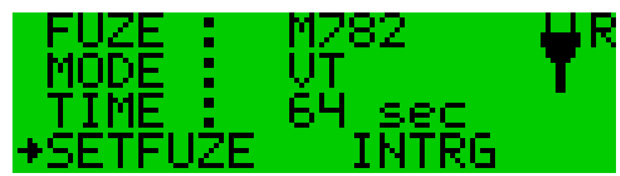
- Uncabled
  - Acts just like original PIAFS
  - Standard Fuze capable



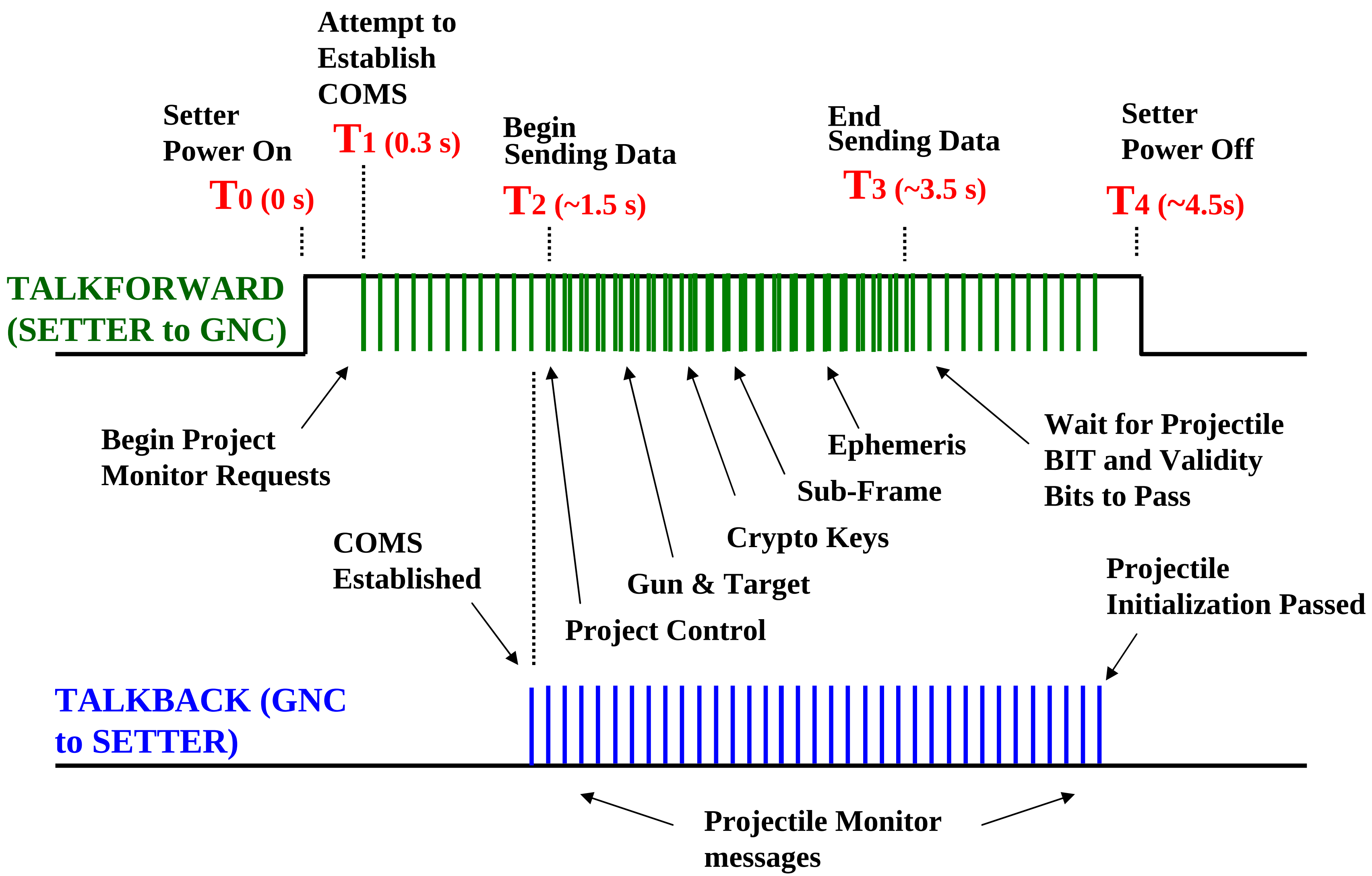
- Cabled Manual
  - Same functionality as Uncabled
  - Receives power externally



- Cabled Remote
  - Receives commands from PIK
  - Standard and GPS Fuze capable

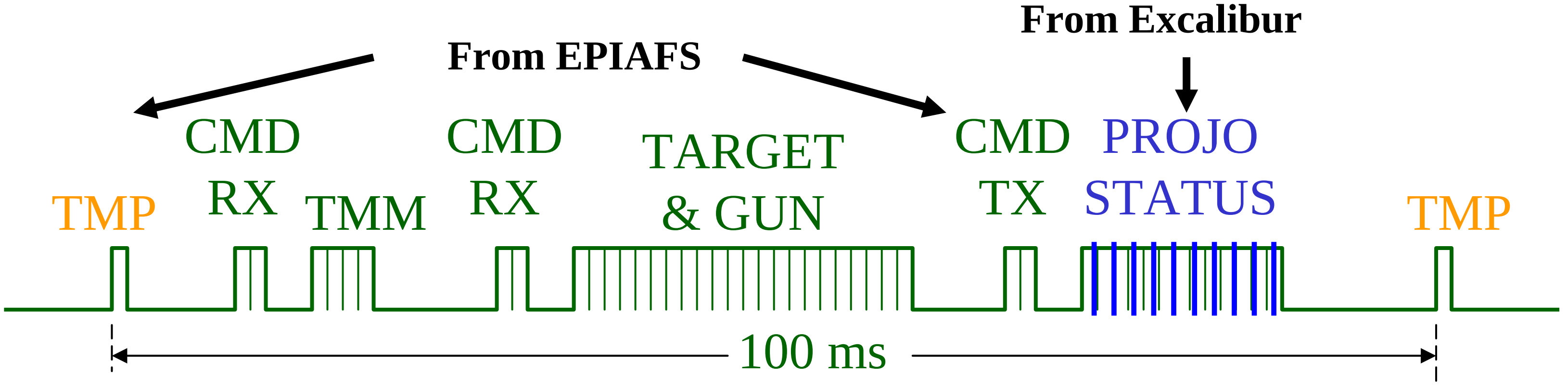


INITIALIZATION TIME-LINE

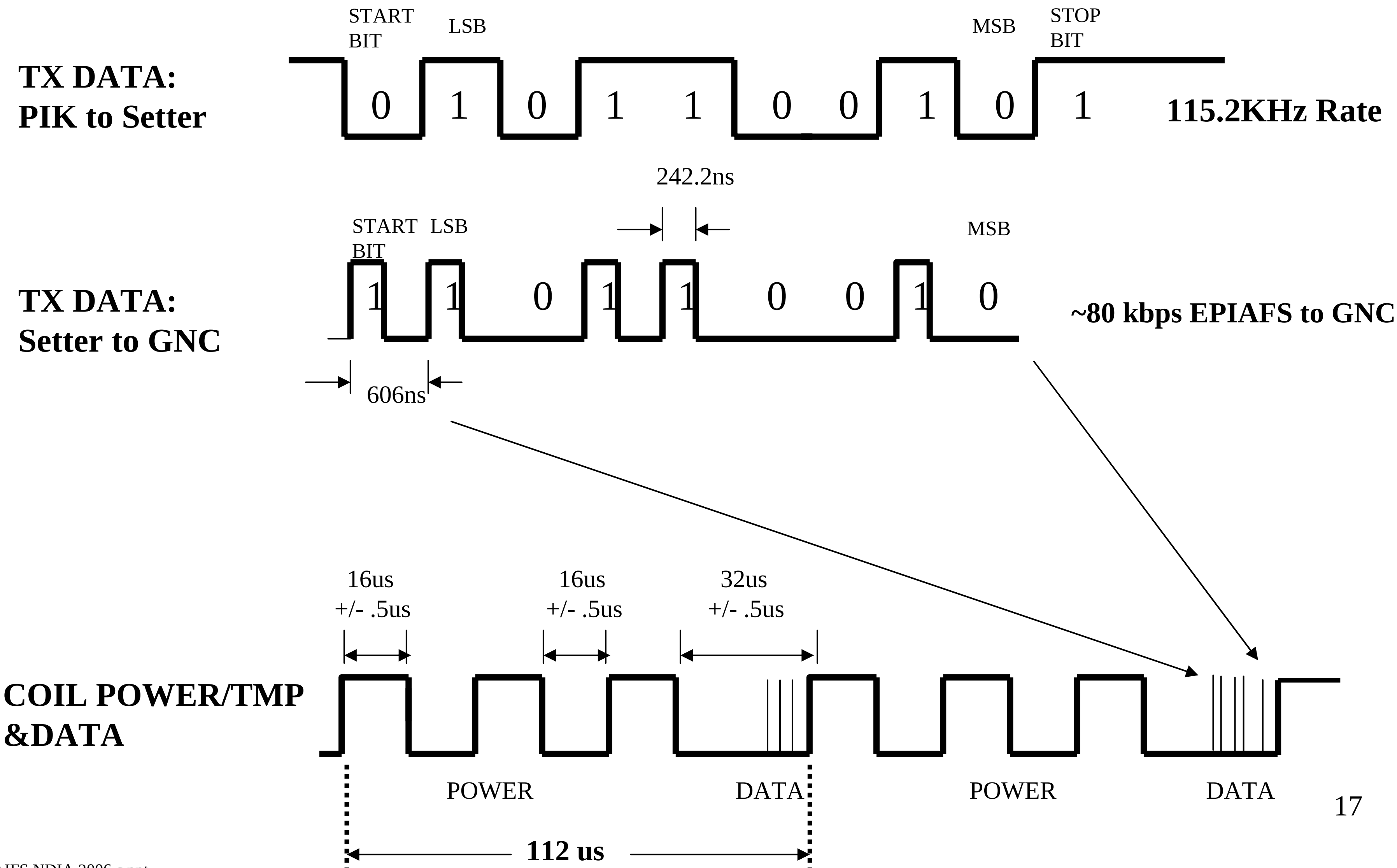


EXAMPLE 100 ms PIK TO PROJECTILE MESSAGE FRAME

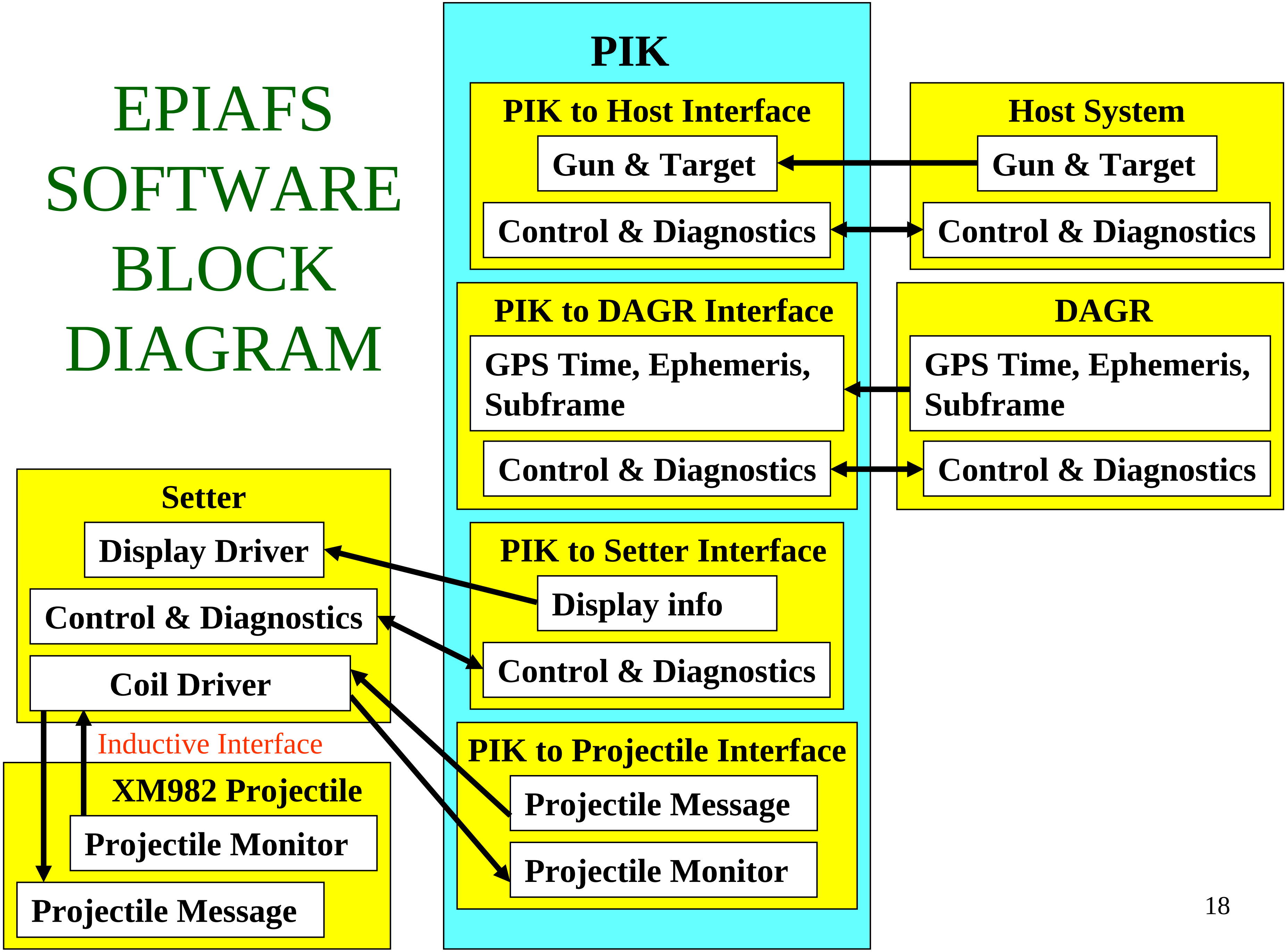
- Sense when Time Mark Pulse (TMP) arrives
- Read Time Mark Message from GPS receiver
- Send Time Mark Message to Projectile
- Send Target and Gun data to Projectile
- Request a Status Message from Projectile
- Receive and Process the Projectile Status



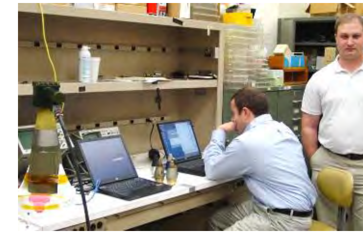
Time Multiplexed Power/Data Format



EPIAFS SOFTWARE BLOCK DIAGRAM

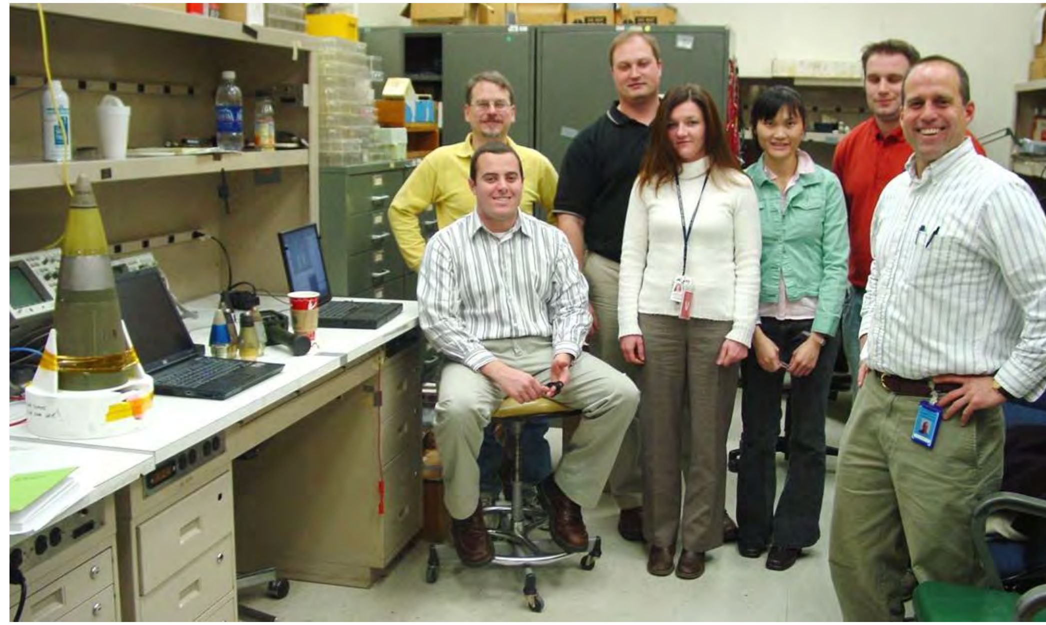


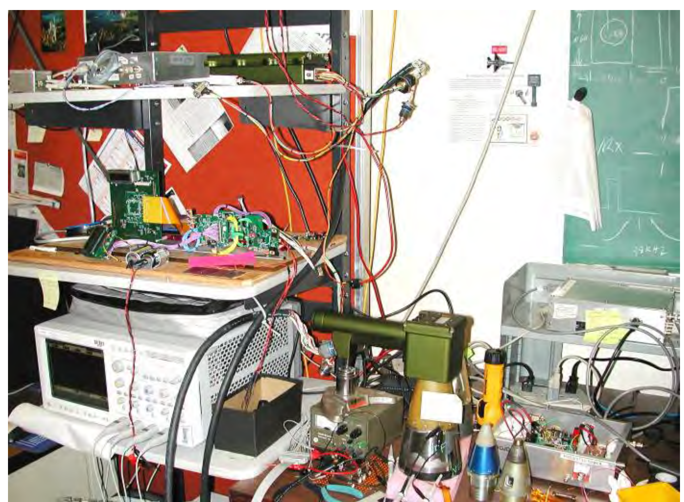
EPIAFS Software Status



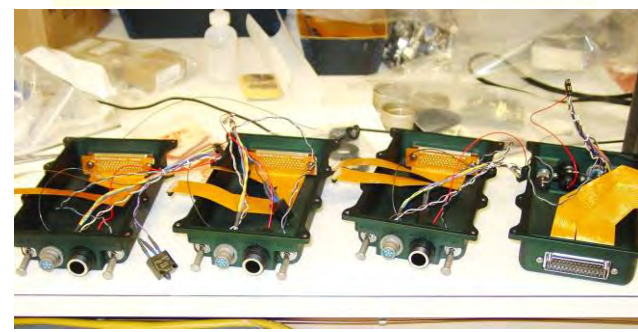
FQT Team

- PIK
  - Written in C++
  - 25,000 lines of code
  - Software FQT Ver 2.6
- Setter
  - Written in C
  - 12,000 lines of code
  - Software FQT Ver 2.1



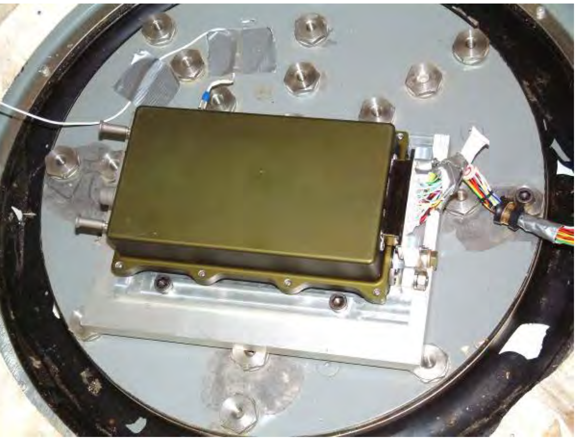


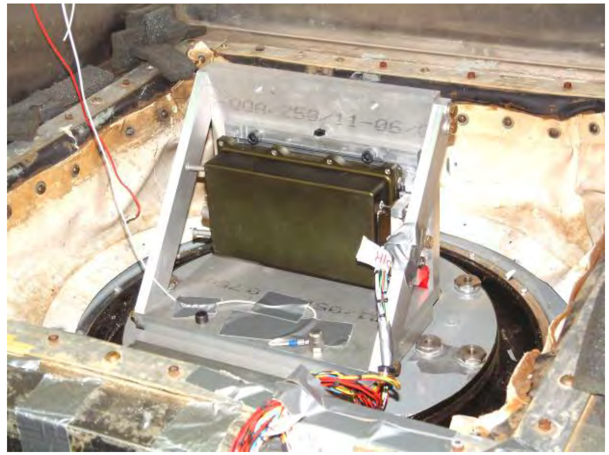
EPIAFS Fabrication



EPIAFS Lab Testing

Shock/vibration





Leak

Temperature

EPIAFS Field Testing

Paladin

Excalibur

Setting Excalibur before firing

Yuma Proving Ground

EPIAFS Laptop Host FCS

EPIAFS ACCOMPLISHMENTS FY06

- Supported development of EPIAFS-Excalibur interface
- Received EPIAFS CONOPS approval for Black Keys from NSA
- Delivered Prototype EPIAFS to PM-CAS
- On-site support at Raytheon of EPIAFS integration
- Delivered laptop based Host Fire Control System to allow early Field testing
- On-site support of Excalibur test firings at YPG
- Supported integration of EPIAFS into Portable Excalibur Fire Control System (PEFCS)
- Delivered Qualification EPIAFS to PM-CAS
- Passed EPIAFS Software Formal Qualification Testing (FQT)
- Supported PEFCS FQT
- Passed DITSCAP
- Authored documents including: Detail specs, Software specs, test plans, system drawing tree, ICD's, CONOPS
- Supported Excalibur, JLW, EPIAFS, and PEFCS E3 testing at WSMR
- Implemented Setter casting to reduce EPIAFS UPC

PLANS

- Complete EPIAFS Qualification Build & Test
- Field units to PEFCS to support Excalibur Early Fielding
- Update EPIAFS TDP
- Support EPIAFS integration into JLW-155 and Paladin
- Support EPIAFS functional integration into NLOS-C
- Support Contractor First Article Build